INTERNATIONAL COOPERATION IN EARTH OBSERVING SYSTEMS

HEARING

BEFORE THE

SUBCOMMITTEE ON INTERNATIONAL
SCIENTIFIC COOPERATION

AND THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

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*Ranking Republican Member.

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INTERNATIONAL COOPERATION IN EARTH OBSERVING SYSTEMS

TUESDAY, JULY 24, 1990

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on International Scientific Cooperation;
and Subcommittee on Space Science and Applications,
Washington, D.C.

The subcommittees met, pursuant to notice, at 1:47 p.m. in room 2325, Rayburn House Office Building, Hon. Ralph M. Hall [chairman of the Subcommittee on International Scientific Cooperation] presiding.

Mr. Hall. The International Scientific Cooperation Subcommittee, in conjunction with the Space Science and Applications Subcommittee, will be meeting today, and I'm pleased to convene this joint hearing as chairman of the International Scientific Cooperation Subcommittee and on behalf of Bill Nelson, Chairman of the Space Science and Applications Subcommittee, who cannot be with us today.

Today's hearing is yet another hearing in a series that the subcommittee has held on international cooperation in the so-called big science projects, such as the Space Station, the Superconducting Supercollider, and the Human Genome Project. Our target today is NASA's Earth Observing System, which certainly qualifies as big science. It's estimated to cost by the end of the decade around $17 billion.

Two years ago, the OECD adopted a resolution which essentially committed the major industrialized countries to fund their fair share of basic scientific research, and Dr. Bromley, Director of the White House's Science Office, followed and endorsed this philosophy in May of this year. I know that Tom Ratchford, who is with us here today and has testified before the various science committees before and has been very generous with his time, has been working hard on plans to develop equitable funding arrangements and satisfactory geographical distribution of the big science projects.

There isn't any question of the need for equitable funding and coordination of research, both land-based and space-based, on the global environment. Just two weeks ago, at the Houston economic summit, the heads of the seven major industrial democracies, seeing the need and recognizing the need for nations to work together to develop technologies and methods for addressing these problems over the long decades, came together. I join what we call the G-7 leaders in my hope that NASA's Mission to Planet Earth, an ambitious endeavor with the noble goal of monitoring global change into the next century, will be a model of international scientific cooperation.

The United States has been criticized, we've suffered some criticism in the past for our approach to international scientific projects. Typically, the critics say that U.S. plans and designs a large project by ourselves and only seriously approaches the international community when it sees the need for international capital and international political support. It's high time to do that at that time if we're ever going to, and this is not an approach that we can afford to take in the future, and I guess that's what these hearings and other hearings along this line are all about.

We'll hear today about NASA's substantial efforts to involve the international community in EOS. We're aware of the significant planning that's already underway internationally, and we know that U.S. instruments will fly on Japanese and European spacecraft and vice versa. We have to plan together. Although these are impressive achievements, I think the bottom line is that the world's space-based environmental research is going to continue to be largely funded by the U.S. taxpayer.

NASA officials have informed us that 60 to 70 percent of the world's space-based environmental studies over the next 15 years will be paid for by the U.S. We will ask our witnesses today whether equitable contributions are being made by our partners, has EOS planned to provide for maximum cooperation with our foreign partners, have we sought our their input with regard to risk management on such a long-ranging and cost intensive project?

In order to answer these very difficult questions, we've assembled two panels, and the first panel is composed of Administration witnesses, and the second panel represents the private sector. We're at a critical point in the EOS Program and indeed in the entire NASA Program. The recent problems that NASA has had with the Shuttle, the Hubble telescope and the Space Station I think only emphasize the need for realistic and careful design and testing of a complex space system.

With EOS, we still have the time to conduct these careful reviews. I know that later in this session the Space Committee will review some of the technical issues associated with the design and testing of EOS. Our purpose here today is to review the institutional design of the program, especially at the international level, to ensure that the cost, benefits and risks of the project are being spread internationally.

We'll challenge all of our witnesses to address the question of whether the international planning process for this program is adequate or whether new institutional arrangements of political agreements may be necessary to ensure that we have the best EOS Program that we can have by the turn of the century.

I will at this time recognize the gentleman from California, Mr. Packard, the ranking Republican on the subcommittee.

[The prepared opening statements of Mr. Hall, and Mr. Nelson follow:]

NEWS from:

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. House of Representatives

Robert A. Roe, Chairman

Robert S. Walker
Ranking Republican Member

Opening Statement by Congressman Ralph M. Hall
Hearing on "International Cooperation in Earth Observing Systems"
July 24, 1990

The Subcommittees on International Scientific Cooperation and Space Science and Applications will come to order.

I am pleased to convene this joint hearing, as Chairman of International Scientific Cooperation and on behalf of Congressman Bill Nelson, Chairman of the Space Science and Applications Subcommittee, who can not be with us today. Today's hearing is yet another in a series that the Subcommittee has held on international cooperation in the so-called "big science" projects such as the Space Station, the Superconducting Supercollider and the Human Genome Project. Our target today is NASA's Earth Observing System (EOS), which certainly qualifies as "big science" – its estimated cost by the end of the decade is $17 billion.

Two years ago, the OECD adopted a resolution which essentially committed the major industrialized countries to fund their fair share of basic scientific research. Dr. Bromley, the Director of the White House's Science Office, endorsed this philosophy in May of this year, and I know that Tom Ratchford (who is with us here today) has been working hard on plans to develop equitable funding arrangements and satisfactory geographical distribution of big science projects.

There is no question of the need for equitable funding and coordination of research – both land-based and space-based – on the global environment. Just two weeks ago, at the Houston Economic Summit, the heads of the seven major industrial democracies recognized the need for nations to work together to develop technologies and methods for addressing these problems over the coming decades. I join the G-7 leaders in my hope that NASA's Mission to Planet Earth, an ambitious endeavor with a noble goal of monitoring global change into the next century, will be a model of international scientific cooperation.

The United States has been criticized in the past for its approach to international scientific projects. Typically, the critics say, the U.S. plans and designs a large project unilaterally, and only seriously approaches the international community when it sees a need for international capital and international political support. This is not an approach that we can afford to take in the EOS program.

We will hear today about NASA's substantial efforts to involve the international community in EOS. We are aware of the significant scientific planning that is already underway internationally. We know that U.S. instruments will fly on Japanese and European spacecraft – and vice versa.

Although these are impressive achievements, the bottom line is that the world's space-based environmental research will continue to be largely funded by the U.S. taxpayer. NASA officials have informed us that 60-70% of the world's space-based environmental studies over the next 15 years will be paid for by the United States. We will ask our witnesses today whether equitable contributions are being made by our partners. Has EOS been planned to provide for maximum cooperation with our foreign partners? Have we sought out their input with regard to risk management on such a long-ranging and cost-intensive project? In order to answer these difficult questions, we have assembled two panels: the first panel is composed of Administration witnesses and the second panel represents the private sector.

We are at a critical point in the EOS program, and indeed in the entire NASA program. The recent problems that NASA has had with the Shuttle, the Hubble Telescope, and the Space Station only emphasize the need for realistic and careful design and testing of complex space systems. With EOS, we still have the time to conduct these careful reviews. I know that later in this session, the Space Subcommittee will review some of the technical issues associated with the design and testing of EOS. Our purpose here today is to review the institutional design of the program, especially at the international level, to insure that the costs, benefits, and risks of the project are being spread internationally. We will challenge all of our witnesses to address the question of whether the international planning process for this program is adequate, or whether new institutional arrangements or political agreements may be necessary to ensure that we have the best EOS program that we can by the turn of the century.

NEWS from:

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. House of Representatives

Robert A. Roe, Chairman

Robert S. Walker
Ranking Republican Member

OPENING STATEMENT
REPRESENTATIVE BILL NELSON, CHAIRMAN
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
July 24, 1990

Today the Subcommittee on Space Science and Applications and the Subcommittee on International Scientific Cooperation will hold a joint hearing on international cooperation in Earth observing systems.

I would like to begin by welcoming our witnesses who will testify in two panels. The first panel of government witnesses will describe the Administration's approach to coordinating our space-based research program with similar programs in other countries. The second panel of private sector witnesses will comment on current international efforts to coordinate Earth observation activities and identify potential concerns.

The purposes of this hearing are to identify what has already been done internationally to coordinate plans for Earth observing systems and to focus on what is still needed for this to become a truly international effort. We realize that many issues in international cooperation remain unresolved as the U.S. and foreign programs are just now taking shape. And we fully expect plans to evolve. Yet we also know that Congressional oversight and public review are most effective before definitive plans are made.

There can be no doubt that Congress and the public support a global change research program that includes a significant space-based component. Nor is there any question that global concerns over climate change require a global response. Yet there are many questions about the best way to organize an international effort in space-based research activities. In this hearing, we hope to raise these questions for discussion. We may not be able to arrive at all the answers today, but we can set the framework for an open discussion as policies are being developed.

One fundamental question we must address concerns the process for international cooperation. The space agencies of the United States, Japan, Canada, and Europe seem to have established good working relations at the technical level of instrument calibration and data validation. Yet these existing cooperative mechanisms may not be well suited to deal with broader issues, such as common data access policies or coordination with ground-based measurements.

Another key issue for discussion will be the establishment of a standard international approach to managing and distributing data collected from the various Earth observation instruments on U.S. and foreign spacecraft. The United States and other countries have proposed different "information policies" for EOS data management and distribution. Reconciling these differences will be a political, not just a technical, task.

Finally, we must consider how the various EOS programs will be coordinated on an international level with other space-based and ground-based research activities. In the United States, interagency coordination of the global change research effort is provided by the Committee on Earth Sciences. No equivalent organization exists for international coordination.

I look forward to a discussion of these and other issues in today's hearing and in future hearings on NASA's Mission to Planet Earth program.

Mr. PACKARD. Thank you, Mr. Chairman. It's a pleasure to join with you and see you back in this seat again. We appreciate your leadership on this issue of the Earth Observing System and international cooperation that relates to it.

I have a prepared statement that I'd like entered for the record, but—

Mr. HALL. Without objection, it will be admitted.

Mr. PACKARD.—in the interest of time and to get to our witnesses, I would just simply say that there are few missions that we will be involved in that are more crucial than the Mission to Planet Earth, and, certainly, questions as it relates to the amount and the level of international cooperation and funding that we will participate in on this project and mission are certainly questions that need to be reviewed carefully and decisions that need to be made.

I'm grateful for the witnesses that are here and for your leadership in this issue, Mr. Chairman, and I look forward to the testimony of those that will be testifying.

[The prepared opening statement of Mr. Packard follows:]

OPENING STATEMENT FOR
HON. RON PACKARD (R-CA)
HEARING ON INTERNATIONAL COOPERATION IN EARTH OBSERVING SYSTEMS (EOS) ACTIVITIES

July 24, 1990

I look forward to today's hearing on what I believe to be one of this nation's and the world's most urgent and exciting scientific programs. The Mission to Planet Earth program has the potential to offer answers to the long-term global environmental crisis we face. The Program further offers new opportunities for enhanced international cooperation in the government, scientific, and corporate arenas.

Currently, the broad political support of the Mission to Planet Earth is evidenced by the strong support of funding despite a budget crisis. The use of the word "Mission" is appropriate as it connotates a special task which requires dedication and commitment unto the task's completion, no matter how long it takes.

What we can and should expect as a result of strong political and financial support is a well-coordinated and efficiently structured program, nationally and internationally. Already, the Committee on Earth Sciences has taken a leadership role in the interagency coordination of our national global change program. Today's hearing will address the plan for international coordination to accomplish the goals of the Mission to Planet Earth.

Around the world, dozens of satellites are under development to study the Earth's oceans, land and atmosphere. Europe, Canada and Japan have already made strong commitments to work with the United States on this critical global Mission. My hope is that the changed political climate would allow countries of Eastern Europe, Latin America, and the Soviet Union to be future partners in this program, and I hope today we will discuss these possibilities.

As the leader in this international effort, the United States is faced with the challenge of reaching the highest level of national and international coordination to minimize redundancy and share costs, while at the same time protecting the future interests of the United States private sector.

The huge scope of this program: data collection, interpretation and dissemination over the next decades, as well as the huge cost, give new meaning to the phrase, "big science project." As this Committee has discussed in past hearings on other big science projects, internationally-shared costs and benefits often present concerns as well as opportunities. The collection of so much new scientific information and its potential for technological development is bound to raise competitiveness questions. The Congress needs to ensure that U.S. companies can gain access to EOS data--and to data from foreign systems--as quickly and efficiently as do companies in Europe or Japan. Commercial restrictions on data use must be carefully evaluated.

The purpose of today's hearing and future EOS hearings is to foster continuous healthy communication between the policymakers, the legislators, the scientific community, and the private sector. I welcome both panels of distinguished witnesses and look forward to discussing this critical program with you.

Mr. **Hall**. Thank you, Congressman Packard.

We recognize David Skaggs of Colorado for any opening statement you may have.

Mr. **Skaggs**. Thank you for holding the hearings. I don't have any statement. Thank you.

Mr. **Hall**. Thank you, sir.

Glen Browder of Alabama?

Mr. **Browder**. I have no questions now or comments.

Mr. **Hall**. Fine.

Mr. **Hall**. We'll get underway with our hearing, then, and we'll call the first panel of U.S. Government witnesses— Dr. Shelby G. Tilford, National Aeronautics and Space Administration; Dr. Robert W. Corell, National Science Foundation and the Committee on Earth Sciences; and Dr. Tom Ratchford, Office of Science and Technology Policy.

Since Dr. Ratchford has made so many trips over here and is an old pro at delivering testimony, we'll start off with you. The chair recognizes you, Dr. Ratchford.

STATEMENT OF DR. J. THOMAS RATCHFORD, ASSOCIATE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, WASHINGTON, D.C.

Dr. **Ratchford**. Thank you very much, Mr. Chairman. It's a real privilege to be here, as always.

I am pleased to have this opportunity to appear before you today to discuss international cooperation in the Earth Observing System. Because global change is truly an international issue demanding attention from all nations, a discussion of cooperation on important aspects of global change research, including EOS, is both timely and useful.

If we measure effort in terms of concrete actions and funding that you've noted earlier, we find that the United States is doing more than any other country to understand and address issues related to global warming and to other major environmental issues.

The Office of Science and Technology Policy is charged with reviewing and coordinating Federal R&D that cuts across the missions of more than one Federal agency and with providing advice to the President on issues of both national and international science and technology policy. In light of these responsibilities, global change is archetypical science policy issue.

Research on global change is being supported by a number of Federal agencies, and global change issues have assumed prominent political visibility, as demonstrated by the President's addressing the plenary meeting of the Intergovernmental Panel on Climate Change in February and hosting a White House conference on science and economic research related to global change in April of this year. Indeed, the issue of global change is at the top of the President's international agenda. He routinely discusses environmental and global change issues in bilateral meetings with heads of State and in larger multilateral meetings, such as the recent economic summit of the industrialized countries in your home State, Mr. Chairman.

OSTP's coordinating function in global change research has been carried out largely through the Committee on Earth and Environmental Sciences, which is one of the committees under the Federal Coordinating Council on Science, Engineering and Technology, the Council having the delightful acronym FCCSET. Allan Bromley, Assistant to the President for Science and Technology, chairs this Council in his capacity of Director of the Office of Science and Technology Policy.

The committee has two primary subcommittees that deal with global change: the Working Group on Global Change, chaired by Dr. Robert Corell of the National Science Foundation, who is on my right on the panel today, and a new Working Group on Adaptation and Mitigation Technologies, headed by Dr. John Knauss of the National Oceanic and Atmospheric Administration.

The CEES and its working groups have done an outstanding job of pulling together the programs of the various agencies involved in earth and environmental science and proposing a coordinating U.S. Global Change Research Program, which would increase Federal spending in fiscal year 1991 by 57 percent over fiscal year 1990, to slightly over $1 billion. It should be noted in this context that global change includes, but extends beyond, the climate change. CEES is working very closely with the international organizations interested in and involved with global change research at both the intergovernmental and the non-governmental level.

We are pleased with CEES' programs and the commitment that Federal agencies have made to global change research, which is unmatched by any country in the world. I'm delighted that Dr. Corell is here on the panel to answer those questions specific to the U.S. Global Change Research Program and the Earth Observing System, which is a part of that program.

NASA's Mission to Planet Earth is a major part of the U.S. Global Change Research Program. It involves several ongoing satellite and research programs and three new initiatives, including the Earth Observing System, or EOS. EOS is a good example of the type of large scale project which is best suited for international cooperation. That is, it is of such magnitude that no one country can bear the financial obligation alone, and the benefits of the program accrue to the world as a whole.

We are giving a great deal of consideration to the generic issue of international collaboration in large basic science projects, the so-called megaprojects. FCCSET's Committee on International Science, Engineering and Technology, another delightful acronym, CISET, chaired by Under Secretary Reginald Bartholomew from the Department of State, has set up a new working group to address the broad range of megaprojects in the basic sciences and international cooperation in these activities.

Not all megaprojects center on the construction of new, large scale research facilities such as Space Station Freedom or particle accelerators. Issues of global scope, such as climate change and mapping the human genome, have become increasingly numerous and pressing. In such areas, the tasks of storing, retrieving and using the truly massive quantities of data require big science approaches and management talents in and of themselves.

For example, space-based systems such as the EOS are expected to send NASA ground stations more than 5,300 terabytes of scientific and technical information in the 1990s. By comparison, the data base of the Social Security Administration, one of the largest non-technical data bases in the Nation, comprises just 1.3 terabytes, or somewhat over 10 percent of the total information in the Library of Congress.

It is clear from this that a heavy component of the Global Change Program will have to include a major data management effort involving more than data collection and the exchange of experimental results. NASA and its international space agency partners have been working together to coordinate not only the hardware being developed for the EOS platforms, but also development of the EOS data and information system. We are pleased with NASA's efforts to ensure compatibility of European, Canadian, Japanese and U.S. instrumentation, which we believe will benefit all users of the data.

NASA's participation in the International Committee on Earth Observations Satellites (CEOS) and Earth Observations International Coordination Working Group is instrumental to successful international coordination of many of the ongoing space-based observation efforts. I'm pleased that Dr. Shelby Tilford is here on the panel this afternoon to address NASA's participation in these intergovernmental coordinating bodies and NASA's efforts to coordinate the EOS with other countries.

Mr. Chairman, you asked several questions in your letter of invitation that I have not yet addressed. Let me take just a moment before I conclude to treat each briefly in turn.

First, should the United States pursue negotiations for a treaty on global change research? The U.S. is very much involved in the international to develop a framework convention on climate change. President Bush has offered, first at the Malta summit with President Gorbachev and later at the IPCC's second plenary session, to host the first negotiating session to develop this framework convention.

It is likely that these negotiations will emphasize the need to develop the large scale, long term global observing systems and the international data management capability which are needed for research on climate change and other aspects of global change. Thus, it can be expected that a framework convention on climate change would include a substantial component on science and research.

Second, what plans are there for including less developed countries, Eastern Europe and the Soviet Union in global change research? Federal agencies, the National Academy of Sciences, and the U.S. scientific community at large are actively promoting and encouraging joint efforts in conjunction with the U.S. Global Change Research Program. Some of these efforts are multi-lateral under the International Geosphere-Biosphere Program and the World Climate Research Program. Others are bilateral.

For example, the U.S. is exploring opportunities for expanded cooperation in global change research with the Soviet Union. Representatives of eight developing nations attended the White House Conference on Global Change in April, at which progress was made toward a common research agenda and partnerships for its conduct. We have actively supported participation by scientists from developing countries in the international planning for these programs.

In addition, the Environmental Protection Agency is developing the Budapest Research Center on Climate Change, as announced by President Bush last fall. CEES and NSF are coordinating interagency funding for the International Institute for Applied Systems Analysis, headquartered in Austria, upon which, Mr. Chairman, you held hearings earlier this year. That institution is becoming increasingly involved in global change research programs with emphasis on both east/west and north/south interaction.

With regard to EOS, NASA is exploring the possibility of direct reception of EOS data at existing satellite ground stations around the world, many of which are located in developing countries.

Finally, you asked what consideration has been given to other models of international cooperation which involve a higher level of shared governance, integration and design. We are pleased with the existing mechanisms for coordinating international space-based global change research efforts. The current structure permits joint planning on the overall mission needs, while at the same time enabling each country to provide its own contribution at a pace appropriate to its capabilities, resources and needs.

These arrangements have served us well in the past. They clearly and logically advance the cause of international global change research while enabling us to preserve the scientific integrity and to assure effective national oversight of Federally-funded programs. This principle of national initiatives and responsibilities within the context of a truly international program is useful to keep in mind.

Mr. Chairman, EOS is only one part of the U.S. Global Change Research Program developed by the Committee on Earth and Environmental Sciences, and the U.S. Global Change Research Program is only one example of the type of basic sciences megaprojects which we in OSTP are hoping to include in a framework that will advance international cooperation in these projects and provide effective, broadly based international scientific and financial commitments to them.

We hope that our efforts will lead to the development of more stable and credible agreements to cover megaprojects in the basic sciences over the longer term. In the meantime, we believe that the Committee on Earth and Environmental Sciences' initiatives to integrate internationally the U.S. Global Change Research Program and NASA's leadership in international coordination of the Earth Observing System both contribute to these efforts.

Thank you very much for your attention. I'd be happy to answer questions at the appropriate time.

[The prepared statement of Dr. Ratchford follows:]

STATEMENT

by
J. Thomas Ratchford
Associate Director
Office of Science and Technology Policy

before
the Subcommittee on Space Science and Applications
and
the Subcommittee on International Scientific Cooperation
of the House Committee on Science, Space, and Technology

July 24, 1990

I am pleased to have this opportunity to appear before you to discuss international cooperation in the Earth Observing System (EOS). Because global change is truly an international issue demanding attention from all nations, a discussion of cooperation on important aspects of global change research, including the EOS, is both timely and useful. If we measure effort in terms of concrete actions and funding, we find that the United States is doing more than any other country to understand and address issues related to global warming and other major environmental issues.

The Office of Science and Technology Policy is charged with reviewing and coordinating federal R&D that cuts across the missions of more than one federal agency and with providing advice to the President on issues of both national and international science and technology policy. In light of these responsibilities, global change is an archetypical science policy issue. Research on global change is being supported by a number of federal agencies, and global change issues have assumed, prominent political visibility, as demonstrated by the President's addressing the plenary meeting of the Intergovernmental Panel on Climate Change in February and hosting a White House Conference on Science and Economic Research Related to Global Change in April of this year. Indeed, the issue of global change is at the top of the President's international agenda. He routinely discusses environmental and global change issues in bilateral meetings with heads of state and in larger multilateral meetings such as the recent economic summit meeting of industrialized countries in Houston, Texas.

OSTP's coordinating function in global change research has been carried out largely through the Committee on Earth and Environmental Sciences (CEES), which is one of the committees under the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET). Dr. D. Allan Bromley, Assistant to the President for Science and Technology, chairs this Council in his capacity as Director of the Office of Science and Technology Policy. The CEES has two primary subcommittees that deal with global change, the Working Group on Global Change, chaired by Dr. Robert Corell of the National Science Foundation, who is also on the panel today, and a new Working Group on Adaptation and Mitigation Technologies, headed by Dr. John Knauss of the National Oceanic and Atmospheric Administration.

The CEES and its working groups have done an outstanding job of pulling together the programs of the various agencies involved in earth and environmental science and proposing a coordinated U.S. Global Change Research Program which would increase federal spending in FY 1991 by 57 percent over fiscal year 1990, to $1.03 billion. It should be noted in this context that "global change" includes, but extends beyond, "climate change". CEES is working very closely with the international organizations interested in and involved with global change research at both the intergovernmental and non-governmental level.

We are pleased with the CEES's programs and the commitment that federal agencies have made to global change research, which is unmatched by any other country in the world. I am delighted that Dr. Corell is here on the panel with me to answer any questions specific to the U.S. Global Change Research Program and the Earth Observing System which is a part of the program.

NASA's Mission to Plant Earth is a major part of the U.S. Global Change Research Program. This effort involves several ongoing satellite and research programs and three new initiatives: the Earth Observing System (EOS), Earth Probes, and attached payloads on Space Station Freedom. EOS is a series of space-based instruments and platforms, developed cooperatively by the United States, several European countries, and Japan, that will help us improve our understanding of Earth processes and global change. It will be our first opportunity to collect data simultaneously on a multitude of different features of the planet's environment. The FY 1991 budget proposes the development of two series of EOS platforms; the first platform is planned for launch in FY 1998. The amounts of data that these instruments will capture and transmit is staggering. A comprehensive data management system is included in the U.S. Global Change Research Program.

We are pleased with NASA's handling of interagency coordination of the EOS program and with their efforts to include and solicit foreign participation in this program. EOS is a good example of the type of large-scale project which is best suited for international cooperation. That is, it is of such magnitude that no one country can bear the financial obligation alone, and the benefits of the program accrue to the world as a whole.

We are giving a great deal of consideration to the generic issue of international collaboration in large basic science projects, the so-called "megaprojects". FCCSET's Committee on International Science, Engineering, and Technology (CISET), which is chaired by Under Secretary Reginald Bartholomew from the Department of State, has set up a new working group to address the broad range of megaprojects in the basic sciences and international cooperation in these activities.

Not all megaprojects center on the construction of new, large-scale research facilities, such as Space Station Freedom or particle accelerators. Issues of global scope, such as climate change and mapping of the human genome, have become increasingly numerous and pressing. In such areas, the tasks of storing, retrieving, and using truly massive quantities of data require "big science" approaches and management talents in and of themselves. For example, space-based systems such as the EOS, are

expected to send NASA ground stations more than 5,300 terabytes of scientific and technical information in the 1990's. By comparison, the database of the Social Security Administration, one of the largest non-technical databases in the nation, comprises just 1.3 terabytes, or somewhat over 10 percent of the total information in the Library of Congress. It is clear from this that a heavy component of the global change program will have to include a major data management effort involving more than data collection and the exchange of experimental results. The U.S. Global Change Research Program includes a comprehensive data management system to address this important need.

NASA and its international space agency partners have been working together to coordinate, not only the hardware being developed for the EOS platforms, but also development of the EOS data and information system. We are pleased with NASA's efforts to ensure compatibility of European, Canada, Japanese and U.S. instrumentation which we believe will benefit all users of the data.

NASA's participation in the international Committee on Earth Observations Satellites (CEOS), and the Earth Observations International Coordination Working Group (EO-ICWG) is instrumental to successful international coordination of the many ongoing space based observation efforts. These bodies promote and encourage complementarity and compatibility among space based systems and serve as the primary international planning, coordination and management bodies for EOS and related programs. While they provide input to, and guidance for, program-level

decisions within individual countries, they do not, nor should they, serve as policy coordination mechanisms. I am pleased that Dr. Shelby Tilford is here on the panel this afternoon, to address NASA's participation in these intergovernmental coordinating bodies and NASA's efforts to coordinate the EOS with other countries.

Mr. Chairman, you asked several questions in your letter of invitation that I have not yet addressed in my testimony. Let me take a moment before I conclude to address each, briefly, in turn.

First, should the United States pursue negotiations for a treaty on global change research? The United States is very much involved in the international effort to develop a framework convention on climate change. President Bush has offered, first at the Malta summit with President Gorbachev and later at the IPCC's Second Plenary Session, to host the first negotiating session to develop this framework convention. It is likely that these negotiations will emphasize the need to develop the large-scale long-term global observing systems and the international data management capability which are needed for research on climate change and other aspects of global change as well. Thus, it can be expected that a framework convention on climate change would include a substantial component on science and research.

Second, what plans are there for including less developed countries, Eastern Europe and the Soviet Union in global change research? Federal agencies, the National Academy of Sciences, and the U.S. scientific community are actively promoting and encouraging joint efforts in conjunction with the U.S. Global Change Research Program. Some of these are multilateral under the International Geosphere-Biosphere Program (IGBP) and the World Climate Research Program (WCRP); others are bilateral. For example, the U.S. is exploring opportunities for expanded cooperation in global change research with the USSR. Representatives of eight developing nations attended the White House Conference on Global Change, at which progress was made toward a common research agenda and partnerships for its conduct. We have actively supported participation by scientists from developing countries in international planning for these programs.

In addition, EPA is developing the Budapest Research Center on Climate Change as announced by President Bush last fall. CEES and NSF are coordinating interagency funding for the International Institute for Applied Systems Analysis (IIASA) headquartered in Laxenburg, Austria, which is becoming increasingly involved in global change research programs with emphasis on both East/West and North/South interaction. With regard to EOS, NASA is exploring the possibility of direct reception of EOS data at existing satellite ground stations around the world, many of which are located in developing countries.

Finally, you asked what consideration has been given to other models of international cooperation which involve a higher level of shared governance, integration and design? We are pleased with the existing mechanisms for coordinating international space based global change research efforts. The current structure permits joint planning on overall mission needs, while at the same time enabling each country to provide its own contribution at a pace appropriate to its capabilities, resources and needs. These arrangements have served us well. They clearly and logically advance the cause of international global change research while enabling us to preserve the scientific integrity and to assure effective national oversight of federally-funded programs. This principle of national initiatives and responsibilities within the context of a truly international program is uselful to keep in mind.

Mr. Chairman, EOS is only one part of the U.S. Global Change Research Program developed by CEES, and the U.S. Global Change Research Program is only one example of the type of basic sciences megaproject which we in OSTP are hoping to include in a framework that will advance international cooperation in these projects and provide effective, broadly-based international scientific and financial commitments to these projects. We hope that our efforts will lead to the development of more stable and credible agreements to cover megaprojects in the basic sciences over the longer term. In the meantime, we believe that CEES initiatives to integrate internationally the U.S. Global Change Research Program and NASA's leadership in international coordination of the Earth Observing System both contribute to these efforts.

Thank you.

Mr. **Hall**. All right. I think, without objection from the committee, we'll save our questions until all have testified.

Before we go to the next witness, Dr. Corell, maybe when I used the word "telescope" that attracted more membership; we have three more very distinguished members on the panel now, and I would first recognize them in the order that they arrived. I believe John Rhodes may have been first from Arizona, distinguished member of the NASA Subcommittee.

If you'd like to say anything, Congressman, I'd be happy to recognize you.

Mr. **Rhodes**. Thank you, Mr. Chairman. I have no opening statement.

Mr. **Hall**. We'll just come in this direction, then. Mr. Rohrabacher from California?

Mr. **Rohrabacher**. Thank you, Mr. Chairman. I'll pass as well.

Mr. **Hall**. And we come to John Tanner from Tennessee.

John, do you have anything?

Mr. **Tanner**. Thank you, Mr. Chairman. I'll pass.

Mr. **Hall**. I'm happy to recognize you and happy to have you aboard.

Sensenbrenner, I don't see him.

Mr. **Sensenbrenner**. I'm here.

Mr. **Hall**. I usually hear you. You're an outstanding member of our committee and ranking, and I'm glad to recognize you for any statement that you'd like to make.

Mr. **Sensenbrenner**. I have no statement.

Mr. **Hall**. Thank you, sir.

All right, we'll move on then.

Dr. Corell, of the National Science Foundation and the Committee on Earth Sciences. I recognize you at this time.

STATEMENT OF DR. ROBERT W. CORELL, ASSISTANT DIRECTOR FOR GEOSCIENCES, NATIONAL SCIENCE FOUNDATION AND THE COMMITTEE ON EARTH SCIENCES

Dr. **Corell**. Thank you very much, Mr. Chairman. It's a privilege and a delight to be here to testify before these two subcommittees and particularly focusing on international cooperation in global change research and especially the role that such cooperation plays in our expanding needs for earth observing systems. International coordination and development are amongst the highest priorities of the CEES, and it is a pleasure for me to give you a sort of progress report of some major developments that have occurred in the past year in the general area of international coordination and cooperation.

As you and this committee know, the U.S. Global Change Research Program was developed by the interagency committee, commonly referred to as CEES, of the FCCSET component of the President's coordinating mechanisms. The program was formally announced in January of last year in a report entitled "Our Changing Planet: A U.S. Strategy for Global Change Research," which accompanied the President's 1990 budget request to the Congress. This report defined the goals, objectives and scientific framework for a U.S. Global Change Research Program, and since that time we've published a number of reports and documents to outline the details of such a research effort.

The planning for that research program is a balanced effort between space- and ground-based research programs and is being addressed from the perspective of several areas. First, the National Academy, more or less representing the U.S. scientific community, is overseeing and coordinating the input from that community to this planning process, an essential component in the development of a sound scientific research program.

The Committee on Earth Science, then, is developing the Federal interagency plan, which in large part receives its input for basic scientific concepts from the scientific community, from our advisory committees, from the programs and plans of Federal agencies, and in cooperation with our partners abroad.

The third major track is that this program, while called the U.S. Global Change Research Program, is designed on the premise that the research effort must be coordinated and must be a balanced effort across nations of the world and funded in a partnership with those countries. The first step that we took in the CEES to build such international coordination and cooperation was to distribute and work with these countries on our plans and efforts, providing them with our strategy plan, our research plan, both to the governments themselves, to research institutions, to scientists, and international organizations across the world.

We began that with our strategy document of January of last year and then followed that up by a detailed distribution of the 1990 Research Plan, which will be updated shortly with a 1991 version, to be out the latter part of this summer. As a result, our plan has become a basic working document among other countries in the world that are following our track in developing global change research efforts and coordinating amongst their agencies of government. That provides us with a new framework for working across the international boundaries.

Thus, by late last year, the international scientific community in most of the foreign governments with global change interests, were both well-informed about our activities and had some detailed knowledge about the breadth and scope of our global change research interests. It is important to keep in mind that, at the time, a number of specific research projects had already begun, such as the World Climate Research Program, and were well underway, established almost 10 years ago, and it's on that foundation which we were able to build both our domestic and our international program interests.

This coordination for these programs and in the future has had a substantial base through the International Council of Scientific Unions, better known as ICSU, and often referred to as sort of the International Academy of Sciences. At the intergovernmental level, the coordination must develop and is developing among the major principal players in the world the World Meteorological Organization, the Intergovernmental Oceanographic Commission of UNESCO, and the UN Environmental Program.

To date, these various organizations have developed broad scientific plans that have evolved into two major components of what one might think of as an international effort of scientific research and global change, namely the World Climate Research Program and the International Geosphere- Biosphere Program. Taken together, they address the major issues of global change.

Late last year, the International Council of Scientific Unions asked agencies of Government, the intergovernmental bodies of the UN, and the scientific community to join together to explore the mechanisms for strategic planning and for detailed implementation of an international global change research effort. As a consequence of that effort, ICSU has restructured its internal machinery for coordination of environmental research, establishing a small group called the Advisory Committee on the Environment that will work across the scientific community and coordinate global change research and related activities within ICSU.

For example, this committee will sponsor in September an International Global Change Forum, which is intended to be replicated every two years, which will promote information exchange and coordination among four different communities that have strong interests in global change research: first, and obviously, the scientific community; second, business and industry; third, intergovernmental UN organization; and finally, the national agencies which fund scientific global change research. ICSU, at the same time, has upgraded its committee structure to support such an activity.

The second action that took place in Lisbon, where this meeting occurred last October, was an initiative that the Committee on Earth Sciences here in the United States took to improve interaction and exchange of information among our international partners that seek global change research interests. We here in the United States invited our counterparts from a number of countries to attend an ad hoc informal meeting in January to explore the possibility of an informal ad hoc set of machinery to work across government boundaries in coordinating and developing a more total international scientific program of research and global change.

Out of that meeting came an agreement among these partner nations to continue such a planning effort. Representatives of funding agencies met again recently only a few weeks ago, in Bonn, Germany. With representatives of CEES-like bodies from around the world and including the space-based interests such as those represented by NASA and the EOS Program here in the U.S. My partner, Shelby Tilford, was present at that meeting and brought to that meeting the perspective not only of the ground-based research interests but, more importantly, the EOS and satellite interests of this country and many countries elsewhere.

We looked at the major scientific research programs. We asked the leaders of the major scientific research efforts, such as the World Ocean Circulation Experiment, the Global Energy and Water Experiment, et cetera, to tell us something about the funding perspectives with at least a five-year time horizon, to look at the personnel scientific requirements needed to engage in such research efforts, and to look in detail at major capital expenditures required to support such efforts, such as satellites, supercomputers, ships, and the like.

An initial comparison out of that analysis that occurred in Bonn, Germany, is that many of these projects are clearly at the stage of implementation, they have adequate resources to begin their field programs, that we in this country and other nations are going to need to ramp up those programs to meet the scientific objectives during the decade ahead. We also see a balance evolving among the principal funding countries and that these key programs will be burden-shared among many participating nations.

This meeting was also preceded by another important meeting, and that was one in which the experts in economics and human dimensions of global change joined together to see whether or not that "community" would work across international boundaries and in what fashion they would be connected to what one might call the natural science interests of the community that are looking at the earth system itself.

Suffice it to say that that community decided to join with the natural science community and create a new body that would work across all the scientific dimensions of global change, from physical oceanography to economics, and this group was born in Bonn, Germany, and is called the International Group of Funding Agencies for Global Change Research. It will have its first fully combined meeting with the human dimensions community in January of this coming year, at which time we will continue to look at a number of fundamental problems that we share across nations in putting together a broad range of scientific research efforts in global change.

Not only will we continue to look at the World Climate Research Program project components and the International Geosphere-Biosphere Programs, but we'll begin to look at other components of research in the human dimensions. While these arrangements may seem to be complex, they are evolving, in our judgment, very rapidly, very satisfactorily and involve the principal and key players in our partners abroad. We believe that the integration of scientific research at the project level is going well and that our job is not so much to worry about how these projects are coordinated within them, but to be sure that the coordination among them is solid and provides what one might call an integrated scientific effort shared across nations around the world.

There are two areas that we feel we must address with particular seriousness in upcoming meetings, the first of which is the implementation of a long term, large scale observing program, which has been talked about on many fronts, of which EOS is a critical component in which our partnership with other countries is essential. Related to that, of course, is what Dr. Ratchford mentioned, the data management program, and we have established within the CEES and amongst the agencies a special working group to address data management and information for global change research.

I might add that we have also identified for this international group of funding agencies a special agenda item to increase the participation of our partners in developing countries where the issues on the table are shared by all countries around the world.

Remote sensing is a key component of the U.S. Global Change Program and is a key component of our international activities. We'll hear more from Dr. Tilford about the details of international coordination in that particular area, but suffice it to say that a space-based component of scientific research is absolutely essential to an internationally-coordinated scientific research program in global change.

It has been a pleasure to be with you, and I thank you for the opportunity to provide this testimony. Thank you.

[The prepared statement of Dr. Corell follows:]

Statement of
Robert W. Corell
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National Science Foundation

Chairman of the Committee on Earth and Environmental Sciences (CEES) Working Group on Global Change

Written Testimony
for the Hearing of the
Subcommittees on Space Science and Applications
and International Scientific Cooperation
of the
House Committee on Science, Space, and Technology

July 24, 1990

International Cooperation in Earth Observing System (EOS) Activities

Thank you very much, Mr. Chairman, for the opportunity to testify before your Subcommittees, together with my colleagues on this panel, on international cooperation in global change research and especially on the role of earth observing systems (EOS) in such research. Dr. Ratchford has provided an excellent summary of our objectives and present efforts to develop international cooperation with respect to both global change research in the broad context and earth observing systems in particular. I will further develop some of major points which Dr. Ratchford has made with respect to our overall global change research effort and, as Dr. Ratchford has indicated, Dr. Tilford will address primarily EOS.

As you know, the U.S. Global Change Research Program (US/GCRP) was developed by the interagency Committee on Earth and Environmental Sciences (CEES) of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) as a key component of the President's overall approach to global environmental change. The program was formally announced in a January 1989 CEES Report entitled: Our Changing Planet: A U.S. Strategy for Global Change Research, which accompanied the President's FY 1990 Budget request. This report defined the goals, objectives and scientific framework for the US/GCRP. Since this initial Strategy report, the CEES has published an FY 1990 Research Plan and an FY 1991 program and budget document that accompanied the President's FY 1991 Budget.

Planning for the U.S. Global Change Research Program is being addressed on a dual track in the United States. The National Academy of Sciences is overseeing and coordinating input from the U.S. academic research community into this planning. The Committee on Earth and Environmental Sciences is developing Federal interagency plans for this Program, based in large part on the input we received and continue to receive from the community through the Academy, from the advisory committees for many of the Federal agencies involved, and through direct communications from scientists and research institutions.

The first step that the CEES took to build international cooperation in this area was to distribute information on our GCRP to foreign governments, to research institutions and scientists, and to international organizations as well. We began this process as soon as our original Strategy paper was available early last year. We followed through with a wide-scale distribution of the GCRP FY 1990 Research Plan late last year. As a result, our Plan has become a basic working document and reference for the planning of other national global change research programs and international efforts also. Within the academic community, the National Academy of Sciences' Committee on Global Change (CGC) had distributed its planning documents for global change research to its counterpart organizations in other countries.

Thus, by late last year the international scientific community and most foreign governments with interests in global change research were well informed as to both the breadth and scope of U.S. interests in global change research. It is important to also keep in mind that at that time a number of specific global change research projects had already been planned and were actually underway and being coordinated effectively at both the intergovernmental and non-governmental level.

This coordination was (and is) being provided at the non-governmental level by the International Council of Scientific Unions (ICSU) and at the intergovernmental level by the three UN organizations involved -- the World Meteorological Organization (WMO); the Intergovernmental Oceanographic Commission (IOC); and the UN Environment Programme (UNEP). To date these organizations have developed broad scientific plans for two major international global change research programs -- the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Program (IGBP).

Late last year ICSU initiated efforts at a global change-related meeting in Lisbon which have resulted in two substantive actions to further develop international cooperation on global change research -- one within ICSU itself and one which involves national funding agencies for global change research. ICSU has set up a small Advisory Committee on the Environment to promote coordination of global change research and related activities within ICSU.

This Committee will also sponsor an International Global Change Forum every two years to promote information exchange and interaction among the four different communities interested in and involved with global change research -- the scientific community; private business and industry; intergovernmental organizations; and national agencies which fund global change research. ICSU at the same time upgraded its Committee for the IGBP and converted it to a permanent status, thus enabling this Committee to more effectively coordinate IGBP activities.

The second action that resulted from ICSU's efforts in Lisbon was an initiative taken by the U.S. CEES Working Group on Global Change to improve interaction and exchange of information on national global change research programs among national agencies that fund such research. As Chairman of the Working Group, I invited my counterparts in a number of other countries to attend an ad hoc informal meeting in January of this year here in Washington. The objectives of this meeting were to exchange information on the ways these agencies fund such research; to identify and review funding approaches that are especially effective; and also to identify problems that can be resolved by exchange of experience among those who have dealt with similar problems in their own countries.

The representatives of national funding agencies met for the second time in June in Bonn, F.R.G., to receive presentations from the scientific planning groups for seven major global change research projects. These presentations were to assist the funding agency representatives in assessing the scientific and funding needs of these projects and in comparing them with the scientific and financial resources that agencies are providing to these projects, thus enabling the funding agencies to identify major overlaps or gaps. The initial comparison indicated that the projects that have reached the implementation stage have received enough resources to begin their field research, but suggested that additional resources will be needed to continue these projects.

This meeting was preceded by the first ad hoc international meeting of experts in economic and human dimensions research related to global change. This meeting was organized and hosted by the Ministry of Research and Technology of the Federal Republic Germany to further consider the need for increased international cooperation in these areas, which were identified at the White House Conference on Scientific and Economic Research Related to Global Change in April. The economists and social scientists at this meeting agreed in Bonn to join with the natural scientists in later meetings of the representatives of national funding agencies for global change research to assure that research programs in these areas are more closely coordinated.

The new joint group will be referred to as the International Group of Funding Agencies for Global Change Research. This Group will hold its first combined meeting in January, probably in London, at the invitation of the United Kingdom's Natural Environment Research Council to consider a broad range of resource issues related to international global change research. This meeting will be held in parallel with the next joint meeting of ICSU's Scientific Committee for Geosphere-Biosphere Research (SCGB) and National

Committees for the IGBP. The funding agency representatives will meet jointly with the SCGB during this period.

While the arrangements I have outlined are complex, they are constantly evolving to reflect the dynamic nature of the scientific projects they are intended to coordinate. As global change research becomes increasingly integrated, both among scientific disciplines and among national programs, so the arrangements for their coordination are becoming integrated as in the International Group of Funding Agencies which I have described. We see no need to convert these arrangements into more formal coordination mechanisms which would very likely be structured along fairly rigid lines that could not easily be modified to reflect the changing needs of these research programs.

However, there are two areas in which greatly increased support from governments will be needed on a long-term basis to meet the needs of both global change research and the development of national and/or international policies regarding global change. The areas I refer to are:

- long-term large-scale observations; and
- data management.

It is essential to develop, implement and maintain major new systems to collect data in the terrestrial, oceanic and atmospheric regimes on both global and regional scales. These systems will have to include both *in situ* and remote sensing capabilities. Intergovernmental organizations such as the WMO, IOC, and UNEP have developed substantial capabilities to promote and facilitate national commitments to international *in situ* systems such as the World Weather Watch (WMO), the Integrated Global Ocean Sciences System (IOC and WMO), and the Global Environmental Monitoring System (UNEP). The development of a framework convention in climate change may provide an excellent opportunity to build on these existing capabilities to meet not only the needs of analysts of climate change, but also the needs of global change research.

Remote sensing activities in support of the U.S. Global Change Research Program are being led by NASA and NOAA. One of the most important of these activities is the development of the Earth Observing System (EOS). NASA and NOAA coordinate their efforts to develop EOS in response to the scientific needs as identified by the U.S. scientific community, again especially through the National Academy of Sciences' Committee on Global Change, and through the CEES in which both NASA and NOAA are major participants.

This concludes my testimony. Dr. Tilford will address international coordination related to remote sensing in support of global change research.

Mr. **Hall**. Thank you, Dr. Corell.

Something I didn't say initially, but I'm sure all three of you well know it, it's good if you can summarize as much as possible and leave us more time, because we have an unusual number of members here to ask questions. You know, do your own thing, but you certainly can summarize, and if you do, your entire statement will be put in the record, unless we have objection.

While I'm at a break here, let me get unanimous consent to have the hearing covered by still photography. Is there objection?

[No response.]

Mr. **Hall**. The chair hears none.

Proceed, Dr. Tilford.

STATEMENT OF DR. SHELBY G. TILFORD, DIRECTOR, EARTH SCIENCE AND APPLICATIONS DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. **Tilford**. Thank you very much, Mr. Chairman and members of the committee. I'm pleased to be here today to discuss the international aspects of the Earth Observing Program.

NASA's Earth Science Program has been developed as an integral part of the Global Change Research Program, as described by Dr. Corell, and an integral part of the CEES Program. Over the past eight years, NASA has worked closely with the scientific community through the National Academy of Sciences and the NASA Advisory Committee to define and initiate a comprehensive approach to looking at the Earth from space.

In 1983, we established the Earth System Science Committee to review what the requirements for a set of observations might be and how these observations and data might be incorporated into a set of comprehensive models to help predict the long term status of this planet. I'm very pleased to see that a number of members of that committee are on the second panel today.

One major conclusion of the committee was that such a comprehensive study of the Earth would require international participation by all nations, both those with space capabilities and developing countries and others with in situ capabilities. A second major conclusion was that the long term calibrated data sets are fundamental if we're ever going to understand, number one, how the earth is changing, and number two, the causes and effects of such changes. That requires that the data be available to the entire international scientific community.

In the past decade, NASA has actively solicited international participation in practically every Earth science space mission that has been flown. This goes all the way back through the NIMBUS series, the Earth Radiation Budget Experiment, TOPEX/POSEIDON, (which is a 50-50 funded program) UARS, TOMS, Synthetic Aperture Radar, the proposed flight of NSCAT and TOMS on the Japanese ADEOS platform, shuttle payloads, now the international polar orbiting platforms and Earth Probes in the late 1990s. We've involved practically every space-based country in the world that has a capability of providing either instruments or interpretation of data.

I think without doubt that these questions regarding what Earth science can provide to better understanding of global change, are inherently global, and our international partners possess important scientific expertise, data analysis capabilities and technology required. The Earth Observing System (EOS) has been planned with this philosophy strongly in mind, with extensive international cooperation on both science and technology involved.

As was mentioned by Dr. Ratchford, the Earth's Observations International Coordinating Working Group is the principal means for such a coordination. Its members include those countries involved in the Space Station polar platform as it was originally initiated, but we have added other countries as they have contributions to make.

Payload planning for the Earth Observing System has been in concert with planning for the European and Japanese platforms to ensure coordinated use of the collective assets of all the partners. This includes data policy, data management, calibration, validation and mission operations. The ICWG has provided the framework for such discussions, and they have been intensive. We meet three to four times a year, and we have evolved very much over the past four or five years.

On a broader level, the Committee on Earth's Observing Satellites (CEOS), as also Dr. Ratchford had mentioned, was created after the 1984 economic summit to look at the broader issues, including not only the Earth Observing System but many of the other observing systems, including SPOT, LANDSAT, et cetera.

Cooperation with developing nations is extremely important. One of the major emphasis of the CEES is to look at such cooperations in terms of the developing U.S. Global Change Research Program and, more importantly, the International Global Change Research Program. This is a very important element. It's our view that the involvement of developing countries in global change research is essential, and we have selected principal investigators from China and Brazil as part of the EOS Program, and we plan to make EOS data available to all users on a non-discriminatory basis throughout the world for research purposes.

NASA anticipates a strong role is supporting U.S. cooperative programs with developing countries through provision of data and participating in joint research activities. One exemplary effort is that we're now undertaking with Brazil.

With respect to the USSR, we think the Soviet Union offers the potential for extremely important expansion in international space cooperation. We don't exactly know how to proceed on a full-up basis with this right now, but hopefully tomorrow or later this week we will sign the implementation agreement in Moscow, NASA officials and USSR officials, for incorporating the first TOMS instrument on a meteor 3 satellite to provide ozone data on a global coverage. Hopefully, that took place this morning, but we haven't had notice yet.

Later on, we expect to fly TOMS on a Japanese satellite and then, finally, in the time frame of the polar platforms, we'll have many, many instruments exchanged internationally.

The ICWG partners are working toward formal agreements confirming the commitments as we move through the selection process, both the United States with the European polar platform and, finally, with the Japanese polar platforms. Data from the various instruments on the various platforms will be incorporated as part of the EOSDIS, and I'm sure you'll hear more about that later.

As Bob mentioned, we are working through the Interagency Working Group on Data Management to formulate a consistent policy in which we can exchange data as an integral part of the Global Change Research Program, and that process will be reviewed by the Committee on Earth Sciences next week.

NASA has participated in a number of meetings, both the CEES and with the private sector. Because of existing legislation, we are sometimes unable to include to the ultimate degree that many industry individuals would desire the ability to provide the same kind of data policy for commercial purposes as we do with the research community. We have been involved over the past few years in many different scenarios of how we fly instruments from the various countries and the world over platforms.

As I say, we've gone through many evaluations, scientific, technical, financial, and taking into account political realities. There's an infinite list of possibilities, and as we move through the selection process in the next two or three years for the various platforms, we would hope to maintain an integrated approach.

While the payload for the total Japanese platform is not yet defined, we are still working very closely with the scientific community to formulate the most scientifically viable program possible. In fact, we participated together with members of the CEOS and the World Climate Research Program in Reading two weeks ago, in which we were looking at the scientific improvements if we were to consider moving the Japanese platform from a polar orbit into a low latitude orbit. That's one of the many possibilities that we think might significantly increase the scientific return.

As my testimony makes clear, NASA considers international cooperation in global change research extremely important. Understanding our environment, and the nature of changes in that environment, is inherently a global concern and requires a global response. I would be happy to attempt to answer any questions you might have. Thank you.

[The prepared statement of Dr. Tilford follows:]

NASA
National Aeronautics and
Space Administration

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Presented by Witness

July 24, 1990

Subcommittee on Space Science and Applications
Subcommittee on International Scientific Cooperation

Committee on Science, Space and Technology

U. S. House of Representatives

Statement by:
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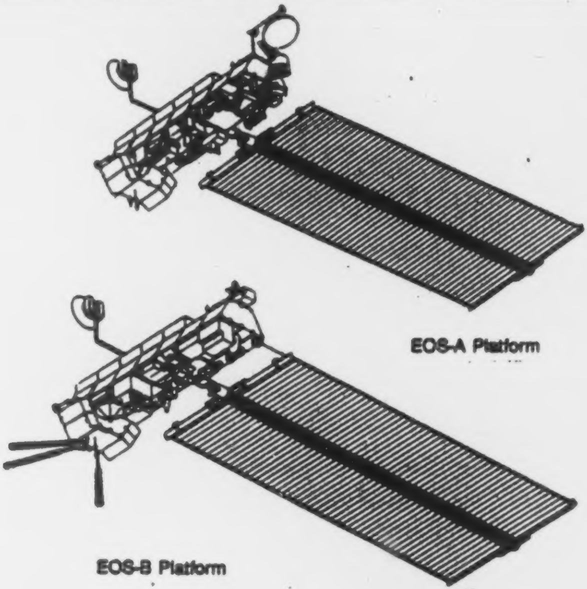

EARTH OBSERVING SYSTEM

101st Congress

STATEMENT OF

DR. SHELBY G. TILFORD

SUBMITTED TO

THE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

AND

THE SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

24 July 1990

Mr. Chairmen and Members of the Committees:

I am pleased to submit this written testimony on NASA's efforts to gain international cooperation in the planning and funding of its space-based efforts to monitor, evaluate and better understand global change. NASA's program has been developed as a integral part of the U.S. Global Change Research Program as defined by the Committee on Earth and Environmental Sciences (CEES, formerly the CES) in "Our Changing Planet: The FY 1991 U.S. Global Change Research Program."

HISTORY OF INTERNATIONAL COOPERATION

Over the past eight years, since the Second UNISPACE Conference in 1982, NASA has worked closely with the scientific community, through the NASA Advisory Committee and numerous Boards, Committees, and Subcommittees of the National Academy of Sciences, to define and initiate a comprehensive approach for the study and assessment of global environmental change. This approach would lead to the implementation of a program of global measurements, process studies, data analyses, and modeling development to improve our understanding of the Earth as a system, how it behaves and responds to perturbations, how it is changing, and the causes and effects for such changes. The Earth System Science Committee, a committee of the NASA Advisory Committee established in 1983 to review the status and requirements for a comprehensive study of the Earth as a coupled system, provided the first in-depth evaluation of the requirements for a study of the Earth as an integrated system. This Committee, chaired by Dr. Francis Bretherton, reviewed the requirements, on a global basis, for understanding how the atmosphere, oceans, land, and biosphere were coupled on a global basis, what data were available, what data were required, and how such data could be incorporated into comprehensive models to provide a long term predictive capability for the future state of the planet Earth.

One major conclusion of this Committee was that such a comprehensive study of the Earth would require international participation by all nations -- both those with space observations capabilities and those capable of contributing in situ observations. Another major conclusion was that long term, calibrated, data sets are fundamental requirements to document, to understand, and to ultimately predict the rate and magnitude of global change and that such data must be made available to the international scientific community. The Bretherton Committee clearly recognized and noted the international (global) requirements for scientific participation in any type of global change research program.

In the past decade, NASA has actively solicited international participation in almost every space mission in Earth Sciences that has been flown, that is under development, or that is currently being planned. A sampling of these missions include:

- The NIMBUS-7 Earth observations platform.
- The Earth Radiation Budget Experiment (ERBE).
- Precise measurements of the Solar Constant.
- The state-of-the-art ocean altimeter experiment, TOPEX/POSEIDON Mission.
- The Upper Atmosphere Research Satellite Program (UARS).
- The Total Ozone Mapping Spectrometer (TOMS).
- Synthetic Aperture Radar (SAR) Observing Programs with the European Space Agency (ERS-1), Japan (JERS), and Canada (RADARSAT), Germany and Italy (SIR-C)
- The advanced Scatterometer (NSCAT) Mission on the Japanese Advanced Earth Observing Satellite (ADEOS).
- The Shuttle Payloads Program.
- The International Polar Orbiting Platforms.
- The Earth Probes missions for the late 1990's.

These international efforts have involved cooperative efforts with the United Kingdom, France, Japan, Germany, Italy, the European Space Agency (ESA), Canada, Brazil, Australia, Argentina, Chile, and the USSR. In addition, NASA has worked closely with the United Nations Environmental Program (UNEP) Global Environmental Monitoring Program (GEMS) and has been a major supporter of the Global Resource Information Database System (GRID).

INTERNATIONAL COORDINATION ON EOS

With respect to specific questions you asked NASA to address:

As is obvious from the above examples, NASA is firmly committed to international cooperation in Earth science. The questions we are studying and the problems we seek to understand are inherently global, and our international partners possess important scientific expertise and data which can contribute to our common success. The Earth Observing System, EOS, has been planned with this philosophy strongly in mind, with extensive international coordination of both the science and the technology involved.

The Earth Observation International Coordination Working Group (EO-ICWG) is the primary mechanism for international coordination of EOS. Its members are NASA, the European Space Agency (ESA), the Canadian Space Agency, and Japan, led by their Earth observation offices, with participation by operational meteorological agencies. Through the EO-ICWG, the EOS Announcement of Opportunity (AO) was coordinated with similar announcements issued by ESA and Japan, providing a mechanism for scientists worldwide to respond to any of the AOs and to have their proposals considered for the collective space system being planned. Payload planning for EOS has been done in concert with planning for the European and Japanese platforms, to ensure coordinated use of the collective assets of the partners.

Work is underway in the EO-ICWG on a number of other important related coordination issues, including data policy, data management, calibration and validation, and mission operations. The EO-ICWG has provided the framework for each participant to maintain total control over their programs while fully coordinating plans and taking into account each partner's interests, contributions, and decisions. Meeting approximately three times per year, the EO-ICWG has been a highly effective group.

On the broader level, the international coordination of the space segment of global change is the responsibility of the Committee on Earth Observations Satellites (CEOS), created as a result of the 1984 Economic Summit. This committee brings together agencies responsible for Earth observations space activities, including the Landsat and the French SPOT systems, the ESA Earth Remote Sensing Satellite (ERS-1) and Japanese Earth Resources Satellite (JERS-1), TOPEX/POSEIDON, the Japanese Advanced Earth Observations Satellite (ADEOS), as well as planned Brazilian and Indian missions. CEOS will meet next in November 1990, when it will likely consider proposed modifications to its Terms of Reference designed to ensure closer coordination with international global change scientific programs such as the International Geosphere-Biosphere Program (IGBP) and World Climate Research Program (WCRP).

COOPERATION WITH DEVELOPING NATIONS AND THE SOVIET UNION

The NASA program is part of the U.S. interagency Committee on Earth and Environment Science (CEES) which is overseeing and coordinating the U.S. Global Change Research Program. Many of the participating CEES agencies conduct research programs with developing countries and with the USSR, and the CEES offers an excellent forum for formulating overall approaches to involve developing countries and the USSR in the global change research and coordinate these activities with the NASA program.

It is our view that the involvement of developing countries in global change research is essential. In response to the EOS Announcement of Opportunity, NASA selected Principal Investigators from Brazil and the People's Republic of China for the EOS program, with other developing country scientists involved in several other investigations. EOS data will be available to all users on a nondiscriminatory basis, so developing country scientists will have the opportunity to obtain and use EOS data and scientific results. Moreover, NASA anticipates a strong role in supporting U. S. government cooperative programs with developing countries through provision of data and participating in joint research activities such as we are now undertaking with Brazil.

The USSR offers the potential for an important expansion in international space cooperation. Later this week in Moscow, representatives from NASA and the USSR should sign the final implementation agreement to integrate and fly a U.S. Total Ozone Mapping Spectrometer (TOMS) aboard an USSR Meteor-3 satellite in July 1991. The TOMS instrument is scheduled to be delivered to the USSR later this year. And just last week, the Earth Sciences Joint Working Group met in Leningrad and now is pursuing several proposals for joint research in Earth sciences. Soviet scientists, like any other researchers, will have access to EOS data for their Earth science research purposes as well. As EOS progresses, it is likely that other opportunities for cooperation will arise.

INTERNATIONAL COORDINATION OF EARTH SCIENCE DATA

The CEOS Working Group on Data has been active in defining common data formats for user products to facilitate the use of similar data from different satellites. The Working Group is also responsible for a common pilot international directory now being installed in the US, Europe, Canada, and Japan. This will permit users to electronically access information about what data resources are available, where they are held, and how to obtain them. The directory will be available through the International Geosphere-Biosphere Program (IGBP) as well. At the November CEOS plenary meeting, additional discussion will be held on the question of electronic networks for data exchange. CEOS is expected to become much more active in the next few years and play the lead role in international coordination across programs.

Through the EO-ICWG, the polar platform partners are working toward formal agreements confirming their commitment that data from all the instruments on all the platforms will be available through a common policy to all users. Whether or not data from non-U.S. platforms physically resides in an EOS Data and Information System (EOSDIS) facility, EOSDIS users will be able to access directory and inventory information about data from other platforms and to place orders and receive data through EOSDIS regardless of who provided the instrument and on which platform it flies. There will be a common directory, electronic linkages between major data centers, and a common data policy supported by formal agency-to-agency and international agreements. Data from non-ICWG sources may be incorporated into EOSDIS, or linkages may be established to the archives where such data reside depending on the particular circumstances. Functionally, these data should be accessible through EOSDIS.

In the United States, working through the Interagency Working Group on Data Management for Global Change (IWGDMGC) and the CEES, agency representatives have developed a Federal data policy for global change research which is now being formally reviewed by each of the participating agencies. It is intended to ensure that global change data are easily available to researchers and to provide the basis for development of an international data policy.

NASA has participated in several meetings with private sector groups through the IWGDMGC and CEES, discussing EOS and data policy. NASA advisory committees include private sector representatives who have participated in reviews of the Earth Observing System and the proposed data system and policies. NASA has gone to considerable effort to publicize its data policy planning for EOS and welcomes input from all sectors on it. NASA supports plans through CEES to establish a joint government-industry-university committee to provide ongoing input for the U.S. Global Change Research Program.

PLANNING FOR EOS POLAR PLATFORMS

The US, ESA, and Japan have had many discussions about possible payload scenarios involving the international suite of platforms. The present scenario represents the consensus view of the best solution to meet the various partners programmatic objectives in light of technical, financial, and political realities as we believe they exist today. There are an infinite list of possibilities but each involves complex trade-offs. The European platform proposal includes a fully subscribed payload with no spare capacity for U.S. instruments, unless other European instruments were displaced. To begin study of an instrument at this point would imply flight on a subsequent platform and would not be realistic for the planned launch dates of either the EOS-A or the first ESA polar platform.

While the payload for the Japanese polar platform is not yet as well defined, there are many candidate instruments which are under consideration in the context of overall international planning. Three weeks ago I participated in a meeting convened by the World Climate Research Program and the Joint Scientific Committee at the European Center for Medium-Range Forecasting at Reading, England, in which CEOS members were invited to discuss the advantages and disadvantages, from a scientific, technical, programmatic, and budgetary perspective, the potential option of moving the Japanese Polar Platform to a 55 degree latitude orbit.

SUMMARY

As my testimony makes clear, NASA considers international cooperation in the Global Change Research Program, EOS, Earth Probes and other Earth science efforts to be extremely important. There are clear scientific, technical, economic, and political reasons to coordinate our efforts with other nations and international scientific organizations. Understanding our environment, and the nature of changes in that environment, is inherently a global concern and requires a global response.

I appreciate this opportunity to discuss this important issue with you, and look forward to answering any questions you may have.

Mr. **Hall**. Dr. Tilford, thank you very much, and we will have a few questions. I guess in any big science project, the major problem we have is financing it and then trying to figure out just exactly how much is our part and how much is their part and who's going to control and all that. I guess you have to have some kind of an idea of a standard to determine what is a fair share of foreign government financial support of space-based earth observations.

How would you do that? Would you do it gross national percent of national product, or would you do it based on a percent of their research budget or a percent of their funding for space projects? Don't you need an international pattern to lay down there for everybody to look at and to have some input? And aren't we headed into that kind of world on these big projects where we have to do them internationally and have to have some help?

Dr. **Tilford**. I think certainly we're headed into those. My concern is at trying to define a template that fits for each individual case. I mean, let me give you one example. I think if we had applied a template two years in terms of what kind of participation we might be working with the Eastern Bloc or European countries, we would apply certainly a much different template two years ago than we would today.

I think it is an evolving situation, and I'm not sure that we can apply a particular formula, because different things relate. I think probably we would want to apply a different template to the developing countries such as Brazil than we would to some of the developed countries. So while I concur in your frustration in trying to define this template, I believe it's extremely important to maximize contributions where the capabilities exist.

One recent example over the past three or four years in which we in NOAA have been involved is trying to convince the Europeans that they should accept a larger portion of the meteorological observations from the operational system point of view. And after many difficult negotiations through the CEOS process, and perhaps a little pressure on our part, Europe finally agreed to accept flying the morning orbit for the meteorological polar orbiting satellites. This is a significant difference from a few years ago.

I would hope that as the Earth Observing Program progresses that we can find much larger participation. I think the contribution by the Japanese is much larger today than it was a few years ago. So while I sympathize with your difficulty, I believe for the most part these things will be driven by policy, and that policy will evolve over a period of time.

Mr. **Hall**. Well, I'd like to hear from Dr. Corell and Dr. Ratchford. It looks like you have to have some pattern there of it. You're going to have those that could participate and won't that want to ride, and yet I don't know of anything that we could turn up that we probably wouldn't share. We always have. We've always paid and shared, too, but as Dr. Tilford said, there was a major change that no one envisioned would be as abrupt as the change in the last year.

Dr. **Corell**. Let take a look at it from the perspective of the scientific programs themselves that rely heavily on earth observing satellites as well as major ground-based programs. We have some experience in mounting major international earth's system scientific research efforts. We've done a good deal of work in the atmospheric sciences this way and the ocean sciences, in particular, and building upon that experience, we're mounting things like the world ocean circulation experiment, TOGA, which is dealing with a southern oscillation in El Nino and phenomena of that nature that have global implications, and a whole series of these.

The meeting I mentioned in my testimony was designed to get at precisely the issue you raise. Are there patterns of funding that we ought to have each country participate in? I think it does rely heavily on some of the things that Shelby said, that there are substantial interests in some countries to deal with a particular part of the research program while others might not have such an interest. Strong interest in "low-lying" countries in questions of global sea level rise have a higher stake in their national policy than other scientific research programs.

You take the World Ocean Circulation Experiment. Over the past several years, the number of countries joining that effort have grown dramatically. The same is true with TOGA. TOGA is probably going to end up with many tens of countries participating, some at very substantial levels and others, because they're resources are not adequate, are participating at a much lower level.

But we're trying very hard as a country not to be the major player in the sense of providing the highest level of financial support to these programs. We are trying to exercise leadership by meeting with our partners abroad, by pointing out the role that they can play because of their scientific talent, their expertise, their national resources, and I think we're making real progress on that front.

But because of the policy implications, these things take negotiations almost on a project by project and a case by case basis, and my guess is that the template idea may be an overarching framework to use for some of our thinking, but in each case we're going to have to negotiate the participation of our partners abroad.

Mr. **Hall**. How really hard are we trying not to be the major one? What percent do we estimate right now that we're going to have to play financially? It seems like I've heard the figure 70 percent.

Dr. **Corell**. Well, I think it varies. Let me take some of the research programs like TOGA. JGOFS, which is the Joint Global Ocean Flux Study, which is looking really at the interaction of carbon cycle between the ocean and the atmosphere. We're probably paying something of the order of 25 percent of that total program, at least the kinds of things we're fielding today. Other countries, particularly Europe, have come on strong, have expressed strong interest in providing substantial ship resources to the conduct of the first major field program in the North Atlantic.

As that program evolves, I think the percentages will move around a bit based on the specific experiments undertaken, but I don't anticipate our breaking the 50 percent mark at any time. In some other cases, because we are leading the development of the program, we're probably paying a higher percentage of the project in its early days, but I know from the perspective of the National Science Foundation, our goal is to always be below the 50 percent level, sir.

Mr. **Hall**. I'm sure there will be those who will ride and drag. We had a catastrophic health care issue here where we tried to take care of the 7 or 8 or 9 percent of the people that absolutely couldn't afford a premium at all under no circumstances, and we had from there up to about 60 or 70 percent of people who could and wouldn't, and that particular bill put it all on those folks that had already provided for themselves. I just think there's a lesson to be learned from that.

My time is almost up. Dr. Ratchford, do you have any statement to make on that?

Dr. **Ratchford**. Well, I would like to add just one point, Mr. Chairman. In your opening statement, you noted that the OECD two years ago had adopted a resolution calling for more equitable funding of basic science between the industrialized countries. They did that as a result of efforts made by Dr. Bromley's predecessor as Director of the Office of Science and Technology Policy, Dr. William Graham.

The reason for this concern on our part is that since the second World War, for various reasons, the United States has been the leader in basic research support world-wide and has funded a very large proportion not only of basic research but also of the large projects in basic research. Discussions are ongoing now within the OECD and bilaterally between our country and others about how best to attain this desired goal of more equitable funding of basic research.

You mentioned a template. The implication was that this template might be applied to the Global Change Research Program. An alternative view, one that we're currently pursuing, is the possibility that this template should be somewhat broader and should be instead of applying to each individual basic research effort be averaged over all basic research activities. Where one country takes a substantial lead in one area, another country takes a substantial lead in another area.

Developing these ideas to their logical extension, that is, the possibility of further agreements implementing the general resolution approved by the OECD, is going to take a lot of time. We look forward to working with your committee, Mr. Chairman, and others on the Hill and in other countries as we attempt to do that over the months ahead.

Mr. **Hall**. Thank you.

The chair recognizes Congressman Packard, ranking minority member of the International Scientific Cooperation Subcommittee. Mr. Packard?

Mr. **Packard**. Thank you, Mr. Chairman.

What assurances is the Administration able to give that private companies, U.S. companies, will have an equal playing field, equal competition with foreign companies in terms of access to the data and information that comes through the EOSDIS Program? Dr. Ratchford and Dr. Corell maybe might wish to address that in that order.

Dr. **Ratchford**. As far as the overall policy is concerned, Mr. Chairman, it is that all researchers have access to the data on an effective basis as possible. Dr. Corell can provide some of the data information as to how that is done.

Mr. Packard. Are there discussions at OSTP in regard to the impact that the data coming from EOSDIS might be weighted in favor of foreign companies or anything of that nature?

Dr. Ratchford. We do not think so, Mr. Packard.

Mr. Packard. That's fine.

Dr. Corell?

Dr. Corell. I was going to suggest that Dr. Tilford speak specifically about what we're doing with the EOSDIS, and I'll speak more generally.

Mr. Packard. Thank you.

Dr. Tilford. We would hope that everyone would have an equal footing in terms of the utilization of data for non- research purposes. I think one of the more crucial issues is right now the interpretation of the Landsat Act as it was modified by Congress. There is a difference in the interpretation, I believe, between certain individuals in terms of how that particular legislation applies. Our concept for EOS is to make the data for research purposes available to everyone in the research community on an international basis on an equal footing.

Therefore, if individuals sign agreements that they will turn their results and their algorithms back into the public domain, then the research will be available free. If there are individuals or groups, whether they be in this country or some other country, who wish to use EOS data but use it for their own personal or profitable reasons, then we will provide that data—not we, but we will provide it as currently indicated by the modified Landsat legislation—for sale, and that includes licensing as currently exists for the EOSAT program for Landsat data.

So I think the same measures that exist today for marketing Landsat data will exist for EOS data, but those will not be the same as for using the data for research purposes and turning it back into public domain.

Mr. Packard. Do we have assurances that Japan or any other country for that matter, but particularly Japan, would impose the same requirements on their private sector?

Dr. Tilford. So far Japan, more than any other country, has adopted the U.S. data policy as is currently proposed, that they will provide their data on a free, non-restricted, open skies policy. Now, how they handle their internal licensing procedures is something we have not discussed with them, but I would expect it would be very similar to what the U.S. has done.

Mr. Packard. Thank you.

Dr. Corell?

Dr. Corell. There are just two things I'd like to add. Dr. Tilford mentioned earlier that we are developing a data and information policy for global change. And it is in its final stages of review, and we hope to have it before the CEES Principals, (the agency heads) next week. That will be a place from which we can then move more aggressively internationally, because we have a coordinated policy statement for the U.S.

The other thing that relates to this is that the CEES Working Group on Global Change has established a special Task Group on industry and its participation in global change. It's a group that is chaired by Dr. Julian Blake, who is an industry "Fellow" currently in OSTP. He is former President of IRI, has a substantial career history of research in industry, and he is helping us amongst the agencies to work more closely with the industrial sector, both in this country and abroad, on these kinds of questions as well as the research agenda itself.

Connected to that is a very substantial international effort on the industrial sector to work them into the global change research agenda. So while it's early, we've had this Task Group only operating this spring and summer, I think we're making the first steps toward being certain that the industrial sector is a participating player in the development of the research agenda and has access to us in the Government so that their concerns and interests are well-represented, so there's a communication channel.

Mr. PACKARD. We have ongoing data collecting systems, the Landsat, and SPOT in France's case, and I'm sure that that data collecting system will in some way be blended into the proposed EOS Program. How will that blending be done between existing programs and new programs, and how will you develop a funding or a pricing policy that will address past collection programs with the new?

Dr. TILFORD. Well, I think the pricing programs will be done on a competitive basis. I mean, we only have one experience, I would have to say, in terms of selling research data in an unblocked mode to the private sector. That is the Large Format Camera data. That's the only example where we sold a set of research data to industry to distribute. In that particular case, we only received one bid for the data, which was $100, and I understand that this particular company is losing something between $20,000 and $200,000 in selling this data.

So I think that will have to be developed, to be perfectly honest. I don't want to imply that the Large Format Camera case was a good one. It's the only one we have under our belt right now. I think this is something that both you here in Congress and we who work in the various aspects of doing the data need to have much dialogue, as well as with private industry, over the next few years. There are many different philosophies.

I think all of our experience in the case of Landsat has been perhaps less than positive in many ways, although in some ways it has been positive. But I think until we try to resolve the Landsat issue perhaps a little bit more clearly that some of these questions will need to await that. On the other hand, we're trying to make maximum utilization of the Landsat experience and EOSDIS, and one of our primary active data archive systems will be located at the current Landsat archive at Sioux Falls, South Dakota, at EROS Data Center.

So we're trying to take into account all the experience there, and we would hope that as this data comes back into the public domain that we can make it available for research purposes as part of an integrated EOSDIS approach, but we still have a few years before we can reach that point, because I believe it will be about three years before the data previous to 1984 comes back into the public domain, and at that time we hope to see an enhanced utilization by both the research community and for other research purposes.

Mr. PACKARD. Thank you, Mr. Chairman. That's all I have.

Mr. **Hall**. Thank you.

The chair recognizes the gentleman from Tennessee, Mr. Tanner.

Mr. **Tanner**. Thank you, Mr. Chairman. I just have one question.

We have had from time to time some—I hesitate to characterize it as misunderstandings—but some concern on the part of our European colleagues about our commitment to the Space Station and our funding mechanisms year to year here in the Congress and so on. Are any of those concerns present in this situation, number one, and number two, are there any other international agreements or things of that nature that need to be done to proceed, and, if so, are there any issues holding back those proceedings that we can help you with?

Dr. **Ratchford**. We have in the past, Mr. Tanner, in this country gained a reputation as being a less than completely reliable partner in large international projects. This is in part due to the nature of our system. We are not a parliamentary democracy. Our President is not a Prime Minister and does not have the party discipline in our Congress that one finds in Europe. Therefore, we have a built-in problem.

Having said that, the kinds of difficulties we face can be addressed if we are able to develop an effective international mechanism for developing our plans on a cooperative basis with our overseas partners in the future. Mr. Hall earlier referred to the fact that sometimes we go to some extent in defining our own programs before discussing them with our overseas partners.

Things are changing, and the agencies are doing a much better job now than they were a few years ago. The other advantage that we have in this particular area is the very effective Committee on Earth and Environmental Sciences, which functions within the FCCSET structure in close coordination with the Office of Management and Budget and with good relations to the appropriate committees here in the Congress.

That committee's efforts in developing and assuring adequate funding for the U.S. Global Change Research Program is a real success story. I can't emphasize how much that is a success. One of the things that we are looking at across the Government as a whole is emulating that success story in other areas because, with the close coordination interagency of these programs, there is a greater degree of confidence on the part of the agencies, on the Congressional committees, that we are in fact approaching the particular issue at hand as a Government and not as a group of independent Federal agencies. So I'm optimistic, Mr. Tanner, about the future.

Dr. **Tilford**. I would have to say that there's no concern as we perceive it in the earth's observing community, being a part of NASA and many of the discussions, and also because originally the polar orbiting platform was an integral part of the Space Station Program. As you know, in the U.S. at the beginning of this year, the Polar Platform Program was completely separated from the Space Station Program.

A similar thing has happened in Europe in the past few months, in that they've completely moved the polar orbiting platform out from under the Space Station Program, such that, I believe, because of the number of intense meetings between the ICWG and the various earth observing partners, we don't have exactly the same situation there in terms of the uncertainty as to the status of the program. I think we've worked from very early in the program to try to define rationale and areas and methodologies for cooperation, such that if there is a change, we try to inform each other quickly, such that we can react or interreact to whatever the situation might be.

We've gone through some difficult times, especially with the Europeans, in trying to learn exactly what size their platform was going to be and what kind of resources it would have, and so as these things move through different stages, we have found that the main thing is to really keep a very close communication between individuals who are participating from various funding organizations as well as the science community. I think it's a trade-off continuously. So there are problems, they have not gone away, but I don't believe they're near as intense here as they are in some other elements of NASA's program.

Mr. **Tanner**. Anything that we can do to help you in this regard—

Dr. **Tilford**. If there is, we will be sure to come up and tell you right quick.

Mr. **Tanner**. Thank you, Mr. Chairman.

Mr. **Hall**. Thank you.

The chair recognizes the gentleman from Alabama, Mr. Browder.

Mr. **Browder**. Thank you, Mr. Chairman. I have a few questions, but in the interest of expediting this I'll try to be succinct and ask the panel to be succinct in their answers, and, Mr. Chairman, if you'll just give me the signal when five minutes is up—

Mr. **Hall**. Four minutes are gone.

[Laughter.]

Mr. **Browder**. Dr. Tilford, you've indicated that the EOS data will be available to both U.S. and international scientific researchers. Is access to international researchers contingent on their government making that nation's data available to U.S. researchers on a non- discriminatory basis?

Dr. **Tilford**. Yes.

Mr. **Browder**. Okay. Have all nations agreed to this?

Dr. **Tilford**. No.

Mr. **Browder**. Can you supply us with the—

Dr. **Tilford**. The Japanese have been 100 percent cooperative in this respect. We have had many, many discussions with Europe. As you know, the European selection process is not exactly like the U.S. selection process, and one of the requirements for selection is having percentage participation of the various countries as they subscribe to the ESA Program.

As a result, there are certain paybacks that are required both in terms of technology, in terms of data, and so forth. Originally, there was a very inward-looking data policy as was originally established by the ERS-1 satellite in which they were not going to make data available to anyone except on a pay-a-big-expensive-price-for-it basis.

As the Global Change Program has developed, not only from the space component but, I think, from the overall global change concerns and the meetings that have taken place both in England and in France and several other places over the past few years, in the last year we have seen a marked change in the attitude of the Europeans in terms of providing data on a quid pro quo basis.

I believe that's coming along fine. It's not coming along as fast as we would like, but there has been significant progress in the last 12 months.

Mr. BROWDER. Well, I would request that you keep us apprised of that. I understand that the information coming back down from the satellite-to-ground station, I understand that the European and Japanese data will be transmitted on a different band width from the U.S. information. If that's true, does that affect data collection and coordination of data?

Dr. TILFORD. Our objective is to make sure that it does not. Now, initially, depending on exactly what configuration of European and Japanese relay satellites exist at that particular time, this may or may not be a problem. This is one of the issues which we've had more intense discussion perhaps than anything else, and even the nearer time frame in the pre-polar platform time frame is to make sure that we do have either through the relay satellites or through direct down-link capabilities the ability to get the data to the ground.

So many of these issues are somewhat simpler than they were two years ago. As we evolve, I think, in the next year or two toward reaching final accord, I think things will become a lot clearer, and we will come back periodically and report to you on this. It is one of the major concerns that is not completely resolved at this time.

Mr. BROWDER. How do we service this satellite? Do we send the Shuttle?

Dr. TILFORD. It is not serviceable.

Mr. BROWDER. It is not serviceable.

Dr. TILFORD. We originally planned to service it, but when we lost the capability of flying the Shuttle out of the Western Test Range that took the man-servicing out completely. We have looked at various options for servicing by remote capabilities. In every case, it looks to be much more expensive and much more risky than developing a platform that would be replaced every five years, along the concept that we are working today.

Mr. BROWDER. Thank you.

Thank you, Mr. Chairman.

Mr. HALL. Thank you. Your time is just exactly up.

We do thank this panel. You've been great, and we now will hear from the private sector. You gentlemen are, of course, free to leave or welcome to stay. We thank you for your time and the time you gave us via telephone and other than the time you testified.

Mr. HALL. All right. We welcome this panel, and, as I've said, you are from the private sector. We urge you to keep your presentation down to four to five minutes. You certainly can summarize, and your entire prepared presentation will be a part of the record.

I presume that you want to go in the order that I have you here, Dr. D. James Baker, Joint Oceanographic Institutions — I'll go ahead and introduce the group—Professor John H. McElroy, College of Engineering, University of Texas at Arlington; Dr. Frederick B. Henderson, III, GEOSAT Committee, Inc.; and Dr. John A.

Dutton, College of Earth and Mineral Sciences, Pennsylvania State University.

The chair recognizes Dr. Baker.

STATEMENT OF DR. D. JAMES BAKER, PRESIDENT, JOINT OCEANOGRAPHIC INSTITUTIONS, INC., WASHINGTON, D.C.

Dr. **Baker**. Thank you, Mr. Chairman, for the opportunity to address the joint subcommittees on this issue of planning and funding of space-based efforts to monitor global change. As part of my work with my institution and with various national committees, I have an interest on behalf of the U.S. academic community to try and stay informed of the issues of space-based and earth-based programs on global change.

Mr. Chairman, in these days when we hear of various problems related to the Space Station and the Hubble Space Telescope, I think it's important to note that the field of earth remote sensing is one that NASA pioneered and one where the achievements have been spectacular. NASA satellites provided the first pictures of global weather 30 years ago. Today, NASA, NOAA and the Department of Defense and commercial and international satellite programs provide a range of information on weather, land and ocean that's unsurpassed.

We should not forget these splendid achievements and should recognize that the current plans for such programs as the World Climate Research Program and the International Geosphere-Biosphere Program are built on these successes. That's not to say that all the NASA satellites are perfect, but we have seen such successes as the NIMBUS-7 satellite which was flown 12 years ago and is still flying and providing important data.

The range of international remote sensing satellites in orbit and planned today is broad, and it ranges from the long and successful experience of the U.S. to the emerging plans of countries like Brazil and China to build and launch remote sensing satellites. International cooperation is providing the user community with remote sensing data for use in a variety of activities, and it's timely to consider what is happening in international studies.

In the letter that I received from the committee, I was asked to address several questions, and I'll just give you a one- or two-sentence answer of each of those, and the details are provided in my testimony.

Mr. **Hall**. And they will be put in the record.

Dr. **Baker**. Thank you.

First, I'm Chairman of the National Research Council panel on the review of the Earth Observing System, and one of the questions was to summarize the findings of that panel. I'm sorry to report that the panel report is not complete. It is still under review at the National Research Council, so I can't discuss the detailed results of that, but I would be happy to return and discuss that with the committee. We expect that the report will be out before the end of August. That's our current planning.

In terms of European and Japanese programs, these programs are strong, and they do support the Earth Observing System planning. One can note that there are many constraints to international cooperation which are not just scientific but which range from politics, national interest, national pride, and national security, not to mention funding. But within these, the NASA and NOAA have done an outstanding job of cooperation in both operational and research satellites. Today, the U.S. program is approximately an order of magnitude larger than either the European or the Japanese program, because we operate a number of operational satellites and a series of research missions, most of which in fact are strongly international.

One question was about current mechanisms for coordinating international space activities. I wanted to say just one word about one of those groups. Dr. Tilford mentioned three that are important; one is the international Committee on Earth Observation Satellites, one is the Space Agency Forum for the International Space Year, and another is the Earth Observations International Coordination Working Group.

Let me just speak briefly to the Committee on Earth Observation Satellites. This is an international committee that is formally constituted and includes the representatives of the space-faring nations for remote sensing. It has been primarily focused on the technical issues of spacecraft instruments and data exchange. It has been less focused on the discussions of international responsibility and cost- sharing.

This is partly due to the fact that space agencies, like all agencies, are constrained by more than scientific needs. We believe, that is, the academic community and the people who look at this from the outside, believe that that committee could be improved in its operations if it had a slightly expanded membership. And this is one place where the U.S. might take the lead in promoting that if the membership were expanded to include some of the major organizations or committees that help define new scientific and commercial programs.

Such organizations could include the World Meteorological Organization, the International Council of Scientific Unions, the United Nations Environment Program, the Intergovernmental Oceanographic Commission. These are the places where programs like the World Climate Research Program or the International Geosphere-Biosphere Program are defined. With both users and planners present, we feel it would sharpen the focus on international sharing of responsibility and cost-sharing.

Another question was involvement of the developing world. The Committee on Earth Observation Satellites involves both Brazil and India, that are developing states that now have satellite capabilities. But other countries that would be users of such data are not as closely involved in the planning for satellite missions. The main issue is data access for developing countries. Access to remote sensing data by countries in the flight path of satellites has been available to an open skies policy, but as countries try to recoup the cost of satellites through the sale of data, it becomes more difficult for the smaller countries.

The main issue is this one of data access. Through the Earth Observing System Data and Information System, NASA plans to provide an unprecedented ease of access to observations, a stated policy that scientists anywhere in the world will have access to the data with appropriate telecommunications equipment. If this policy can be carried out, then there will be good interaction on an international level.

The one potential point of concern is the current policies governing the use, distribution and cost of LANDSAT and SPOT data. Eventual recovery of the real cost of satellite data is often necessary in developing a commercial venture, but it has an adverse affect on both non-commercial users, such as scientific researchers, and on developing countries. The high cost of data to researchers can impede the flow of scientific research and leave valuable unstudied. Not all data needs to be included in the EOS Data and Information System, but means should be found to include adequate subsets of such data in global change archives so that global change research can proceed with full information.

Mr. Chairman, thank you for the opportunity to make these points to the committee.

[The prepared statement of Dr. Baker follows:]

TESTIMONY TO THE

HEARING ON INTERNATIONAL SCIENTIFIC COOPERATION IN EARTH OBSERVING SYSTEMS (EOS) ACTIVITIES

OF THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
AND THE
SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
OF THE
U.S. HOUSE OF REPRESENTATIVES

BY

D. JAMES BAKER
JOINT OCEANOGRAPHIC INSTITUTIONS INCORPORATED
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WASHINGTON, D.C. 20036

JULY 24, 1990

Mr. Chairman, thank you for the opportunity to address the joint Subcommittees on the issues of international cooperation in the planning and funding of space-based efforts to monitor global change. I am D. James Baker, President of Joint Oceanographic Institutions Incorporated, a non-profit research management organization that plans and manages large research programs for the oceanographic community. The major activity of Joint Oceanographic Institutions is the management of the Ocean Drilling Program, an international activity that currently involves 19 countries.

I am also chairman of the National Research Council's Panel to review NASA's Earth Observing System in the Context of the U.S. Global Change Research Program, a member of the Panel to Review the FY 1991 U.S. Global Change Research Program, and a member of the Committee on Global Change. I have been involved in international scientific activities through my positions as an officer of the Joint Scientific Committee for the World Climate Research Program and co-chairman of the international Scientific Steering Group of the World Ocean Circulation Experiment which is one of the major projects of the World Climate Research Program. I mention these activities to show that I am familiar with the issues involved in international cooperation in both space-based and ground-based programs in the earth sciences.

Mr. Chairman, in these days when we hear of various problems relating to the Space Station and the Hubble Space Telescope, I think it is important to note that the field of earth remote sensing is one that NASA pioneered and one where the achievements have been spectacular. NASA satellites provided the first pictures of global weather 30 years ago. Today NASA, NOAA, the Department of Defense, and commercial and international satellite programs together provide a range of information on weather, land and ocean that is unsurpassed. We should not forget these splendid achievements and should recognize that the current plans for such programs as the World Climate Research Program and the International Geosphere-Biosphere Program are built on these successes.

The range of international remote sensing satellites in orbit and planned today is broad, ranging from the long and successful experience of the U.S. in weather and land-sensing satellites to the emerging plans of Brazil and China to build and launch a remote sensing satellite. This business is no longer restricted to a small number of countries. International cooperation is providing the user community with remote sensing data for use in scientific, commercial, and government activities. It is important and timely to consider the issues involved in international cooperation in Earth sensing satellites.

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The testimony will be ordered following the questions that were asked:

1. Findings of the NRC Panel.

The report of the Panel is still under review in the National Research Council, and therefore I am not free to discuss any conclusions. The final report of the Panel is expected to be released before the end of August. I would be pleased to return at your convenience to discuss the conclusions of the report. Therefore this testimony should be viewed as my personal conclusions based on my experience with various international programs as noted earlier.

2. Overview of earth observation activities in Europe and Japan.

In Europe, operational weather observations are provided through EUMETSAT with a geostationary satellite. There is a continuing commitment to the geostationary program. ESA is planning to launch an Earth Resources Satellite ERS-1 in 1991. A continuation, ERS-2, has recently been agreed to. A joint Earth radiation budget mission (SCARAB) between France and the USSR is planned for 1992. France is supporting a joint mission with the U.S., TOPEX/POSEIDON, for ocean topography measurements for the World Ocean Circulation Experiment. France also has committed to an on-going series of land remote sensing satellites, the SPOT series. Data from these satellites is available commercially. Plans are now in place for a polar platform as part of the Earth Observing System. Other satellites, such as a gravity field mission and an ocean color mission, are also under discussion.

In Japan, there is a continuing commitment to a geostationary meteorological satellite. An ocean sensing satellite MOS-1b is now flying and providing high-resolution data. A Japanese Earth Resources Satellite with emphasis on synthetic aperture radar is proposed for flight in 1992, and the Advanced Earth Observation Satellite (ADEOS), which will have Japanese and U.S. instruments aboard, is scheduled for 1995. A joint U.S./Japanese mission, the Tropical Rainfall Measurement Mission, is scheduled for 1996. Plans are now in place for a Japanese contribution to the Earth Observing System, but whether this platform will be in polar orbit or inclined orbit is still under discussion.

The European and Japanese programs are fully supported by their governments and there appears to be strong commitment for long-term support. The scientific emphasis of these programs complements the U.S. programs. In terms of relative level, the U.S. funding is at least an order of magnitude higher because the U.S. supports a strong operational satellite program (several in low earth orbit by NOAA and DOD and two NOAA geostationary satellites) as well as a diverse research program from satellites and the space shuttle (UARS, TOPEX/POSEIDON, LAGEOS, SIR, ATLAS, SEAWIFS, TOMS, TRMM). The U.S. is planning a 15-year series of two polar-orbiting satellites as part of the Earth Observing System.

3. Current mechanisms for coordinating international space activities related to Earth system science.

There are several mechanisms for coordination in place today. Perhaps the most effective of these for the purposes of interest here are three: the Committee on Earth Observations Satellites (CEOS), the Space Agency Forum for the International Space Year (SAFISY), and the Earth Observations International Coordination Working Group (EO-ICWG). The CEOS has tended to focus on technical issues of spacecraft, instruments, and data exchange. The Committee has been rather successful at doing that, as we can see from the successful satellite meteorological system and search and rescue systems.

CEOS has been less focused on discussions of international responsibility and cost-sharing. This is partly due to the fact that space agencies, like all agencies, are constrained by more than scientific needs. There are political constraints and funding constraints. Brazil, Canada, France, India, Japan, the U.S., and the European Space Agency are currently members. To help the CEOS focus on scientific program needs, it would probably help if the membership were expanded to include some of the major organizations or committees that help define new scientific programs. Such organizations could include the World Meteorological Organization, the International Council of Scientific Unions, the United Nations Environment Program, and the Intergovernmental Oceanographic Commission. Committees such as the Intergovernmental Panel on Climate Change, the WMO/ICSU Joint Scientific Committee for the World Climate Research Program and the ICSU Special Committee for the International Geosphere-Biosphere Program might also be represented. With both users and planners present, it would sharpen the focus on international sharing of responsibility and cost-sharing.

Stronger use of the EOS-ICWG and the SAFISY would also be useful. The EOS-ICWG has already proved to be useful in that it provides a forum to discuss what platforms and instruments are required for the EOS. The SAFISY has made earth observations a high priority for the International Space Year.

4. Other models of international cooperation.

As we look towards the 21st century, it is clear that the needs of global change research together with the constraints of limited world resources will drive closer cooperation. A higher level of shared governance, integration, and design might well be both necessary and feasible. As new mechanisms are considered, it is important to recognize that the highest levels of coordination must not become simply debating societies. Large committees with diffuse responsibilities and membership will simply not be effective. The first logical steps would be towards expanded groups as proposed above.

5. Involvement of the developing world.

As I mentioned above, the CEOS includes Brazil and India, both developing states that have satellite capabilities. Other countries that would be users of such data are not as closely involved in the planning for satellite missions. The main issue is data access for these developing countries. Access to remote sensing data by countries in the flight path of satellites has generally been subject to an "open skies" policy: if the country wishes, the data from those satellites have been made available and can be collected through a local ground station. But today, as countries try to recoup the cost of expensive systems, data is often sent to only a limited number of ground stations and must be purchased by others. The issues are discussed further in section 8 below.

6. and 7. Instrument development and flight on other platforms.

This topic will be addressed in the NASA testimony. In summary, both Europe and Japan are involved in developing instruments that will be part of EOS and that will be complementary to the proposed U.S. complement. Moreover, there have been agreements about flying certain U.S. instruments, for example, the Laser Atmospheric Wind Sounder (LAWS) is currently scheduled to fly on the Japanese platform.

8. International aspects of the Earth Observing System Data and Information System.

The main issue here is one of data access. NASA plans to provide an unprecedented ease of access to observations, with a common data policy for the entire international suite of data. It is NASA's stated data policy that scientists anywhere in the world with appropriate telecommunications equipment will have access to EOSDIS provided that they adopt the standard research agreement about making available derived data, algorithms, and models. If this policy can be carried out, then there will be good interaction on the international level.

One potential point of concern is the current policies governing the use, distribution, and cost of Landsat and SPOT data. Eventual recovery of the real cost of satellite data is often necessary in developing a commercial venture, but it has an adverse effect on both noncommercial users such as scientific researchers and developing countries.

The high cost of data to researchers can impede the flow of scientific research and leave valuable data unstudied. The current legislation intended to protect the commercialization of Landsat remote sensing activities prevents the inclusion of these data in EOSDIS unless the government purchases the data for that purpose. Other similar data, such as that from the French SPOT system, also must be purchased. Not all such data must be included in EOSDIS, but means should be found to include adequate subsets of such data in the global change archives of EOSDIS so that global change research can proceed with full information.

Mr. Chairman, thank you for the opportunity to testify on these important issues. I look forward to further discussion.

Mr. **Hall**. Thank you for summarizing.

We would recognize at this time Professor John H. McElroy, College of Engineering, University of Texas at Arlington. It's all I can do not to say, "Hook 'em horns," and I'm not going to say that, because that shouldn't be in the record.

[Laughter.]

Mr. **Hall**. Professor, we're happy to have you.

Dr. **McElroy**. I did graduate from the University of Texas at Austin.

STATEMENT OF DR. JOHN H. McELROY, DEAN OF ENGINEERING, COLLEGE OF ENGINEERING, THE UNIVERSITY OF TEXAS AT ARLINGTON, TEXAS

Dr. **McElroy**. Dr. Baker mentioned the past successes of earth observations, and this committee, of course, has a long committee record of examining those successes. The Mission to Planet Earth aspires to combine the most advanced features of all of those past and present missions and indeed features that were unimagined in those programs as well. It intends to incorporate them into an ambitious program of observations to understand our planet as a whole and to do so with an international constellation of spacecraft.

Further, it plans to integrate all these data streams, U.S. and international, to create an integrated multi- dimensional view of the earth from which conclusions can be extracted regarding the direction and pace of global change. It's important to recognize that the Mission of Planet Earth will measure such subtle changes that measurements are expected to be required to be made over a 15- to 20-year period and with consistent instrumental calibration that permits data taken in the first year to be compared with confidence to that taken, say, in the 10th, 12th or 20th year. This has never been done before and is a major scientific and engineering challenge.

Now, if we put all of the EOS engineering issues aside as solved, all the scientific measurements that are chosen to be made are now settled, and we put aside all the international agreements on the exchange of data—of course, none of these are indeed solved—we have overriding management issues which remain. In my opinion, the latter issues are the most difficult aspects of the program and the hardest ones to resolve. The most singular aspect of the Mission to Planet Earth, in comparison to other even very long duration NASA programs, is that it is for all practical purposes a permanent activity, and it must be so managed.

Indeed, it is larger, more costly, more international in character, more complex, and potentially of longer duration than activities to which our Government presently devotes entire Federal agencies. For example, NOAA, EPA, and the FAA. Because of its duration, it is a misnomer to consider EOS a project or even a program. It is a scientific and operational institution and must be considered in that vein and established as an entity having institutional properties of charter, resources, facilities, structure, policies, practices, and perhaps most important corporate memory.

The least significant part of EOS may be the engineering aspects of the space segment. However difficult that engineering may be or become, it is only one of the means that will be employed to meet the objectives of the effort. The effective integration of a broad, multi-disciplinary international cadre of scientists and engineers into this program is a far more difficult and important task, in my mind.

Now, interagency programs are not unprecedented. Thoroughly successful ones, however, are few. The Mission to Planet Earth requires the enthusiastic support of a number of U.S. Government agencies. It requires the commitment of their personnel, their data, as well as agency priority in the conduct of the effort and advocacy in the budget process. Difficult trade-offs will have to be made within and among the space segments, earth segments, and scientific research tasks. Authoritative leadership is going to be vital, but authoritative leadership is not something that's provided by an interagency committee.

Now, other witnesses have spoken of cooperation, coordination, committees, panels, but precious little has been said about focused research management. The Mission to Planet Earth has no less of a need for scientific leadership than does the SSC or the human genome experiment or the Space Station project or any other massive, big science project.

Now, if I am concerned about interagency efforts, that concern extends even more strongly to international ones. The effort that is planned is in all respects inherently international in scope—data requirements, sensing systems, scientific research. I have concern about the long term durability of interagency coordinating mechanisms, but those concerns are amplified when international elements are considered.

Very firm agreements are going to have to be reached regarding the assignment of responsibilities. If a set of nations is to rely upon the timely availability of other nations' data that are essential to the interpretation of the data they are in the process of collecting, then there must be assurances that the data will indeed be provided, and I think a laissez-faire approach is simply not going to work.

The protective mechanism which was alluded to earlier of withholding data from parties that renege on an agreement doesn't work. It doesn't work, because it is only the entirety of the data set which is going to yield the subtle answers that are required in global change.

Now, this is not to say the United States has not had hugely successful experience with international and cooperative ventures. It has indeed. However, the past experience has been principally with missions where there is a degree of autonomy. Highly satisfactory results flow independently from the individual missions, and we have only sought enhancement of those results by cooperation in the past. The NASA EOS mission is not the same, in my opinion. While it will indeed produce certain fine results, the full vision and ambitious objectives of the Mission to Planet Earth will only arise with full international contributions.

Now, I have suggested in my prepared testimony a number of organizational strategies, which I will not go over in detail, but let me simply make one point. Under the current organizational structure, the largest piece of the funding is buried at the third tier management level of the agency. Now, third tier management is performed admirably well. I could not speak more highly of what has been achieved to date. But nevertheless, we are talking about being buried in an organization which is currently consumed by such things as Hubble, future planetary missions, and the whole Space Science and Applications Program of NASA. We are talking about an activity which is equal in size to the entire program which already exists there.

I believe that that is not a satisfactory arrangement for the future. Now, my own preferences would be to do some fairly drastic steps, which I outline in the testimony. I understand that there will be a considerable reluctance to taking any of those. But the one option which I do not believe to be satisfactory is simply to accept the status quo as we move to a $1 billion to $1.5 billion per year type of total investment.

I believe settling the U.S. domestic scene is vital before we can effectively negotiate authoritative agreements with the international community. I am a wholehearted supporter of EOS, but, frankly, I know of no more important mission that the space-faring nations can undertake. It is certainly my number one priority for NASA to be involved in. But at the same time, I can also conceive of no more complex scientific task than that which is laid out by the Mission to Planet Earth, and I believe that it requires authoritative scientific leadership and indeed management.

Finally, I think that loosely treating the international agreements or saying that, "Well, it would be nice if they proceed, but they are not essential" is really not the satisfactory approach to doing those agreements. Thank you, Mr. Chairman.

[The prepared statement of Dr. McElroy follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

July 24, 1990

Statement of

Dr. John H. McElroy
Dean of Engineering
The University of Texas at Arlington

Hearings on

International Cooperation in
Earth Observing Systems (EOS) Activities

Before the

Subcommittee on Space Science and Applications
and the
Subcommittee on International Scientific Cooperation
Committee on Science and Technology
U. S. House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittees:

I am pleased to again have the privilege to speak to the subcommittees on the important topic of international cooperation issues associated with the so-called Mission to Planet Earth.

Introduction

The assessment of the earth from space is an unchallenged success of the space program. Weather, land, and ocean satellites have all made major contributions to daily activities, economic development, and the enhanced understanding of our planet. The past successes have, however, been simpler to achieve than those that we seek in the future. Even those simpler tasks challenged our engineering, scientific, and organizational skills.

We think of the weather satellite as an uncontroversial development that moved easily into operations, at least that is the perspective from 1990. From 1960, 1970, and even 1980, the perspective was quite different. Among the questions raised were:

- Who should run the program? Should NASA take on an operational role?
- Who should develop the satellites? Should another agency develop space system expertise?
- Who should determine the design of the satellites? Should operational entities such as the National Weather Service control design, or are they not progressive enough?
- At what point should a design be frozen for operational use? Should it be a Tiros or a Nimbus design?
- How good are the data?
- How are the "vast" [at that time] quantities of data to be distributed and used?
- Who is to receive the data and at what cost?
- How are the measurements to be integrated into forecasting models?
- Should the system be a national or an international one?

These were all controversial questions, and the answers that were eventually agreed to were not preordained or self-evident. In some cases, the questions or their derivatives remain without a complete or final answer.

The Landsat series of satellites, which followed the weather satellites and have now moved to the private sector, have had an even more difficult gestation period. Their data streams dwarfed those of the weather satellites and the user constituency remains in a developing state -- although increasingly skilled in recent years. Opinions remain split on the value of the data, with the scientific community and some in the private sector endorsing it, while others remain skeptical. At one point in the Landsat program, more than 25,000 scenes were backlogged and delivery times stretched into the years.

Ocean satellites are in an even more rudimentary state of development. Coverage has been sporadic and experimental rather than operational. The value appears great, but the market beyond research remains uncertain. The most notable ocean sensor, the synthetic aperture radar with its all-weather capability, produces a huge data processing load that exceeds that of any other earth sensor. Nevertheless, the results obtained to date are striking and give promise of having both research and operational value.

Interestingly, all of the above issues are being raised again in the context of the Earth Observing System (EOS). The Mission to Planet Earth aspires to combine the most advanced features of all of these past and on-going missions (and features unimagined in these programs as well) into an ambitious program of observations to understand our planet as a whole, and to do so with an international constellation of spacecraft.

Further, it is planned to integrate all of these data streams (U.S. and international) to create an integrated, multidimensional view of the earth from which conclusions can be extracted regarding the direction and pace of global change. While the data from multiple sensors has been integrated on a small scale, and even among international partners, it has never been attempted with such grand scope.

Finally, the Mission to Planet Earth will measure such subtle changes that measurements are expected to be required to be made over a 15 to 20 year period, and with consistent instrumental calibration that permits data taken in the first year to be compared with confidence to that taken in the 10th or 12th or 20th year. This has never been done before, and is a major scientific and engineering challenge.

An Institution Not a Program

When all of the EOS engineering issues are put aside as solved, all of the scientific measurement choices are made, and all of the international agreements reached on the sharing of data (none of these three items being in that state today), the overriding management issues remain. In my opinion, these latter issues are the most difficult aspects of the program, and the ones hardest to resolve.

The most obviously unique aspect of the Mission to Planet Earth in comparison to other even long-duration NASA programs is that it is for all practical purposes a permanent activity, and must be so managed. Indeed, it is larger, more costly, more international in character, more complex, and potentially of longer duration than activities to which our government presently devotes entire federal agencies, e.g., the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), the Federal Aviation Administration (FAA), etc.

Instead of having a degree of autonomy, with clear management responsibility, it is at the third or fourth management tier within the NASA structure, with a commensurate degree of management attention and access to agency resources. At a time when NASA has a very full set of responsibilities ranging from operating the Shuttle to planetary missions to preparing for a Mars mission, the ability of an agency head to focus on the huge challenges of EOS is necessarily limited. Further, the fundamental character of EOS as an exploration of essentially all of the earth sciences is totally dissimilar to other NASA functions, where the focus is on the space element.

Because of its duration, it is a misnomer to consider EOS a project, or even a program; it is a scientific and operational institution, and must be considered in that vein and established as an entity having the institutional properties of charter, resources, facilities, structure, policies, practices, and – possibly most importantly with time – corporate memory.

The least significant part of EOS may be the engineering aspects of the space segment, however difficult that engineering may be or become, because it is only one of a number of means that must be employed to achieve the objectives of the effort. The effective integration of a broad, multidisciplinary, international cadre of scientists and engineers into this program is a far more important element.

Twenty-Year Programs and the Issue of Corporate Memory

A person's working life is forty or perhaps fifty years. A person's association with one activity is some fraction of that time, possibly five to ten years or even less in many cases. People are promoted, transferred, lose interest, become ill or disabled, and die in programs of all durations, but increasingly so when the duration of an effort exceeds a person's normal period of involvement in any single activity.

Therefore, the people who have originated the Mission to Planet Earth will largely not be present when it is completed, or even while it is underway. Measurements that begin in the late 1990's and extend for twenty years, and that were conceived of in the early 1980's, span a total period of nearly 30 years. A good many of us who were at the outset look with anticipation to the first launch of an EOS spacecraft in the late 1990's, but have no expectation of seeing results, as even that date is close to or past our normal retirement date.

The implication of such long-term activities is that they must be structured in a manner that the effort proceeds smoothly in spite of changes of personnel. There cannot be the normal principal investigator who tends a program from birth to completion. One needs only to look at any of the national laboratories and count the number of scientific leadership changes that occur in a twenty-year period, yet they have retained a coherence of direction and purpose in spite of those changes because of their properties as institutions.

Institutions develop a corporate memory and capabilities, and can sustain purposeful activities well beyond the involvement of particular individuals. They can create complex facilities, as will be required to process, archive, and analyze the huge data sets of the Mission to Planet Earth. Institutions can establish interorganizational links and agreements and coordinate the efforts of a globally distributed set of investigators on a scale far beyond that of the normal five or ten-year program. At the same time, employing the management structures used for a five to ten-year NASA program in such a venture seems to me to be a direct path to failure.

The Interagency Element

Interagency programs are not unprecedented; thoroughly successful ones are, however, few. The Mission to Planet Earth requires the enthusiastic support of a number of U.S. government agencies. It requires the commitment of their personnel, their data, as well as agency priority in the conduct of the effort and advocacy in the budget process.

I believe that the federal agencies have done an admirable job to date in coordinating the diverse interests that surround the EOS mission. However, interagency coordination committees are not well known as effective long-term mechanisms for program management. The coordinating board established to oversee NASA-DOD relations has at best a checkered history. A cynical view would be that the usual interagency program oversight committee begins with fanfare, and a meeting attended by well-briefed, senior officials who have the authority to make decisions. The next meeting is attended by badly-briefed designees whose authority extends only to carrying back requests to the senior officials. The third meeting is conducted by so-called "working level" officials with no authority to commit the agency they represent to anything, and possibly not even the authority to gain access to the original senior official, and perhaps not even the designee. While this is a cynical view, it represents a serious organizational trap for the Mission to Planet Earth. It also is a further consideration urging the creation of an institutional base that is exclusively committed to the Mission, as opposed to being buried at the third or fourth tier of an agency.

My personal belief is that such an activity must exist at no less than a second-tier level in the responsible agency, and would preferably be a free-standing entity in its own right at a level such that its chief would be comparable in authority to an Administrator of EPA, NOAA, or the FAA. If the latter is done, then interagency coordination can be achieved at the agency head level, and at the only level with the authority to commit the agencies to specific actions.

Difficult tradeoffs will have to be made within and among the space segments, earth segments, and scientific research tasks. Authoritative leadership will be vital.

The International Element

The concern expressed regarding interagency organizational matters applies even more strongly to international ones. The effort planned is in all respects inherently international in scope, date requirements, sensing systems, and scientific research. While I have expressed concern above with the long-term durability of an interagency committee as the program management and coordination body, the concerns are amplified when the international elements are considered.

It is self-evident that the Mission to Planet Earth cannot be realistically conducted by the United States exclusively. Access to foreign scientists and data are required. The foreign data are from satellites and from ground or sea-based observations. The overall cost is far too high for any one nation to proceed unilaterally, and the benefits are far too widely spread to warrant a unilateral approach in any event. Further, the intellectual challenge is likewise of too great a scope for one nation to undertake.

At the same time, the same tradeoffs that must be made domestically are required on a global scale. Very firm agreements must be reached regarding the assignment of responsibilities. If a set of nations is to rely upon the timely availability of other nations' data that are essential to the interpretation of the data they collect, then there must be assurances that the data will indeed be provided. The protective mechanism of withholding data from parties reneging on an agreement is not adequate protection, because it is the entirety of the data set that gives it value. Therefore, it is not sufficient for only informal agreements and coordinating mechanisms to be employed.

The United States has had very successful experience with international cooperative ventures. Active, vigorous coordination is routinely conducted in earth observations among the American, Asian, and European countries. When the coordination is done through authoritative bodies of agency heads or comparable individuals, it is almost invariably effective. However, the past experience is with missions that have a degree of autonomy. Highly satisfactory results flow from them individually, and it is only the enhancement of those results that is sought through the collaborative exchange of data. The NASA EOS mission is not the same. While it will indeed produce fine results in its own right, the more ambitious objectives of the Mission to Planet Earth are unattainable in the absence of international contributions.

There are international coordinating bodies for earth observing satellites, however they focus on the space segment, rather than the totality of the earth sciences. I believe that the international coordinating, and even management, function must address the total scientific questions being addressed and the most effective means to address them.

The changing political climate in Eastern Europe raises questions today regarding the participation of the U.S.S.R. and Warsaw Pact nations in EOS. As some of the most seriously damaged parts of the Earth lie in these nations, they have much to contribute in data and experience, and a strong motivation toward greater understanding and corrective action. The Mission to Planet Earth is the most important environmental and space program of our age; it would be unthinkable not to seek the participation of all nations.

The same is true of developing countries. While they cannot contribute hardware, or large amounts of funding, they can contribute data and knowledge that will be indispensable to the interpretation of the space-derived data. Obviously, the overall needs of developing countries are staggering and only partially addressable through a greater understanding of our planet. They still have people, including noted scientists, who can contribute to EOS and exploit its results in their own region.

An Organizational Path for the Mission to Planet Earth

In my opinion, the Mission to Planet Earth cannot be based within the divisional structure of the Office of Space Science and Applications (the third or fourth tier management level I mentioned above). As a minimum first step, it must be spun off into a separate "Office" level structure within NASA.

A preferred first or second step would be its establishment as an independent entity, but I recognize the difficulties inherent in that recommendation. A possible approach in creating an independent entity would be for the new entity to subsume both the relevant responsibilities of NASA, as well as most of NOAA's (the scientific as opposed to the regulatory activities) and portions of the responsibilities of other agencies. In this manner the critical mass could be marshalled to conduct the effort. That would obviously be resisted in a classic "turf" fight.

If the Mission is placed under an authoritative director, then that person can be charged by the Administration and the Congress with establishing the international coordination mechanisms with the support of the Department of State. Those who are exceptionally observant, or alert to Washington nuances, will have noted that I said "entity", rather than "agency" above. It is not at all clear to me that the structures of a federal agency are most suited for EOS. There are other alternatives, both nationally and internationally.

Envirosat

I have long advocated the spin-off of operational earth observations systems to the international private sector, an approach I dubbed "Envirosat". I still propose such a step, but it is complementary to the above scientific research, rather than competitive. The Mission to Planet Earth assumes throughout the availability of the operational satellite data, and my view is that the private sector should be the source, with the government being a customer, rather than a builder and operator.

The question remains, however, whether the Envirosat concept can be extended to encompass the considerably larger EOS effort. Those familiar with the Envirosat approach may recall that I have proposed two entities, Envirosat-USA and Envirosat-International. The former was the U.S. entity representing the United States in the overall body, Envirosat-International. The analogy is that of Comsat in Intelsat and Inmarsat. The most important and first step that I proposed was not the formation of the international entity, but the putting of the U.S. house in order by creating a properly chartered domestic entity. I did not then feel, nor do I feel today, that international negotiations can be productive in the absence of the first step.

Therefore, I believe that the United States must first create a domestic entity for the conduct of EOS and the Mission to Planet Earth. When that task is complete, the next step of greater international integration can be examined. The domestic alternatives I see are, in ascending order of priority:

- An "Office" level activity within NASA.
- A new federal agency combining elements of NASA, NOAA, EPA, and others.
- A new federally-funded, but not Civil Service, entity in the mold of the national laboratories, and notably patterned after the Jet Propulsion Laboratory, and under NASA direction, but with interagency oversight.

I favor the latter quite strongly. The current Civil Service system has too many restrictions and too low a salary structure to attract the first-rate people that are required to meet the truly enormous challenges of EOS. NASA has been able to retain high-quality people because of its considerable organizational *esprit* and *elan*, and the excitement of early spaceflight. This cannot continue indefinitely, and the exodus of experienced scientists and managers from NASA over recent years has been noted by many observers.

In particular, the lifestyle and compensation of a senior scientist in academia or industry today is far superior to that in Civil Service. The Civil Service has been battered by those in several administrations, and its members made the target of special abuse. Barbs and abuse directed at miscreants struck home instead in talented engineers and scientists. Not surprisingly, when the leaders of a government declare verbal war on their own employees, the attractiveness of federal employment diminishes rapidly, and most rapidly in those with the greatest talents and consequent mobility. The Jet Propulsion Laboratory has thrived because of its freedom from Civil Service regulations, and that freedom must be replicated for EOS to succeed.

After a satisfactory organizational arrangement is reached domestically, the question of international oversight of the total effort must be addressed. My recommendation is that the process begin through a meeting of the principal international participants, with representation of both the space and earth science and/or applications interests. In many senses, this would be analogous to the organizing conventions that led to the formation of other international bodies. The national representatives should be of sufficient level to present authoritatively their national positions, and to negotiate the assignment of responsibilities. This is a difficult, and indeed cumbersome, process, but I believe it to be essential to gaining firm commitments to such a long duration and expensive effort.

The Gordian Knot of Data

For EOS to be successful, an international spiderweb of data exchange agreements must be achieved. Some strands in the web will be communications links analogous to the current Global Telecommunication System (GTS) used to exchange weather data. Other strands will be postal systems used to exchange data records.

NASA is making a strong effort to anticipate the difficulties and prepare for them. Committees with international membership are discussing data standards and data exchange timelines. The EOS Data and Information System (EOSDIS) is under intensive study. Unfortunately, there is no past success at which to point as a model, only partial models that have been partially successful – or completely unsuccessful and providing thereby useful object lessons albeit inadequate direction.

As in the case of EOS as a whole, the issue with EOSDIS is one of ensuring that the best possible intellects are brought to bear on what will inevitably be a most daunting problem. I believe that the problem is soluble, but it will be expensive and hugely difficult. It will be difficult in negotiation (domestically and internationally), engineering conception, development, and operation. Nothing that NASA or any other agency has done compares with the full vision of EOSDIS.

Conclusions

I am a wholehearted supporter of EOS. I know of no more important mission for the spacefaring nations. I also know of no more complex scientific task than that laid out as the Mission to Planet Earth. It is ambitious and essentially a permanent undertaking.

My personal belief is that new organizational approaches must be employed to meet the needs of this mission, both domestically and internationally. It cannot be only a NASA mission, although the NASA cadre is vital to its progress, and I believe that the strictures of the Civil Service System may preclude its effective conduct within that framework. I, therefore, propose that alternative organizational structures be explored, and that the Jet Propulsion Laboratory could be an example of a successful approach.

At the same time, the program is inherently international. It is costly, and therefore requires the assets of all nations, both in space and on earth. It is intellectually challenging and can benefit from the intelligence and knowledge of people from all nations. Finally, it is global in its data requirements, so all nations have information to offer. Therefore, firmer agreements must be reached regarding international responsibilities and commitments. In the interim the most important first step is the establish the responsible, authoritative U.S. entity, followed closely behind by the creation of the international earth science coordinating body for the overall oversight of the effort.

Mr. HALL. Thank you. I recognize Dr. Henderson at this time.

STATEMENT OF DR. FREDERICK B. HENDERSON, III, PRESIDENT, THE GEOSAT COMMITTEE, INC., NORMAN, OKLAHOMA

Dr. HENDERSON. Thank you, Mr. Chairman and members of the subcommittee. I'd like to express on behalf of the members of the GEOSAT Committee and the resource industries user community, which we generally represent, that we appreciate the opportunity to testify here today.

As private sector industrial users we have generally not been included in NASA's planning and, accordingly, cannot knowledgeably comment on NASA's efforts regarding international support and planning for the EOS Program to monitor, understand and develop predictive models for global change. We welcome this opportunity, however, to express our concerns on international data policy, cooperation and cooperative research for better global change research and environmental management.

The resource industries which support the GEOSAT Committee are also major factors in producing resources needed by society and by the nature of our industry are major contributors to man's impact on the earth's environment; some of it necessary, some of it manageable. In any case, NASA, the United States Global Change Research Plan, industry and the public will benefit from greater international cooperation and participation of both industry and Government in developing the EOS and EOSDIS Programs.

Industry can and would provide extensive ground truth measuring capabilities, data bases, data base management experience, research facilities and support, if it can be properly brought into the program.

In my letter that was directed to me, I also was asked several questions, and I'll try to briefly summarize my responses.

Regarding our comments on increasing the international character of space-based research, what does increased internationalization raise for U.S. industry, and what opportunities does it create, I think Congressman Packard touched on our most pertinent area of concern. Most of the corporate members of the GEOSAT Committee are international. Many are non-U.S. companies who use satellite remote sensing globally.

We are continually confronted more and more by international governments' increased emphasis on improving environmental management to actually participate in resource development within those countries. This is true of industrialized countries and third world countries. We support NASA's efforts to expand the international character of the EOS and EOSDIS systems, but it is very important, in our opinion, that other countries' institutional relationships between industry and government must be well understood.

While we do not know all of the arrangements NASA has in its negotiations, it is our concern that NASA may negotiate EOS data exchange agreements with other countries without ensuring that U.S. industrial access policies are equivalent to those of other countries. In general, the data access policy of other countries in regard to industrial access are far less restrictive than those proposed in the United States.

We are concerned, for example, in the case of Japan we are well aware that they are leaders in international cooperation between NASA and NASDA, but the instruments that are being built are also being supported and funded by MITI, an industry-represented agency in Japan, also involvement of JAROS, a major industry role for petroleum mining and engineering companies as advisory groups and funding groups that relate to the development of these programs: JERS-1, ADEOS and the ITIR systems. It is simply beyond our comprehension that MITI and industry will not receive that data more openly than it's being offered at the present time to U.S. industry for research as well as commercial purposes.

Other countries have similar mechanisms in place for sharing of government and industry data more cooperative than in the United States. I recently completed a study for NASA's Stennis Space Center entitled "Commercial Objectives, Capabilities, and Opportunities for International Earth Observation Programs, 1990 to 2000," which illustrates in a simple way our understanding of mechanisms of government- industry cooperation in research, development and the use of satellite data and how other countries are better organized to cooperate and share such data than the United States. I've offered sections 3 and 4 of this report to your committee for inclusion in the record.

The GEOSAT Committee urges Congress to provide continuing oversight to help assure that NASA's international agreements will, to the maximum extent possible, ensure that industrial data access policy for EOS data will apply fairly and equally to U.S. industry and the industry of the foreign partners with whom NASA has data exchange agreements.

Regarding the potential benefits and opportunities, they are many-fold and great. Clearly, our international companies are interested in participating in global research studies, as we have a major role to play in managing the environment.

The second question was has sufficient industry input to development of cooperative data policies, so on and so forth, adopted by NASA and elsewhere around the world. I will simply state we believe that we believe there has not been sufficient industry input into the development of cooperative data policy by NASA and are not aware of any adequately mechanism currently being planned for.

In recent years, NASA has removed industry participation from the Office of Space Science and Applications Advisory Committee. In effect, it does not have direct input from the user community and industry in the United States that I'm aware of.

Regarding the requirements that NASA is having for industry for research, the terms that have been used by other speakers here today and by NASA are broadly for basic science and for research. But, generally, as we understand these requirements, for example, providing algorithms, complete reports, and so on and so forth, these are generally viewed at this time as being difficult to work with from a research mode with an industry which has its own requirements, its own proprietary interests.

On the other hand, industry must learn to cooperate in a better manner than it has done so far. In this effort, we have submitted our concerns in detail in a previous written statement to this committee in your hearings on 1 March, and I've included that for reference.

Regarding the third question, in the view of GEOSAT, has NASA proposed adequate processes for making data from the EOSDIS available to the user community, again, NASA has not yet proposed adequate processes for making data from EOSDIS available to the user community, if in fact it includes the industrial user community.

To reiterate our concerns stated in the previous testimony, we believe, of course, that NASA's EOS data policy is a major improvement for basic science over past restrictive principal investigator practices. However, the policy does not recognize the inherent need for data access for applied research by industry prior to the industrial user community's needs for commercial access for actual commercial use. There is a difference between these two requirements.

While industry must broaden its willingness to publish the results, we believe the EOS data policy must include the ability of industry to acquire data for applied research purposes, as distinct from operational commercial use. This is very important for industry to come into cooperative research such as we're exploring with the Committee on Earth Sciences. We therefore recommend that NASA's EOS data policy be developed in terms of three levels of access: basic science in the public domain at minimal cost and commercial access at the appropriate time under the appropriate mechanisms, as supported by Dr. Tilford, but also a third area must somehow be provided, and that's for applied research with reasonable publication requirements.

I'll skip a couple of these other questions and submit them in the interest of time. I would like to respond to one here in terms of the question asked if the GEOSAT Committee participants are of multi-national character, which, of course, they are, and the question was regarding whether any of them or any of their entities could provide one-stop shopping for end users for data related to global change study.

In our organization, we're not aware of any multi- national member who is in a position to facilitate one-stop shopping for the end user, but I would commit to you to become familiar with the way the RADARSAT International is being developed in Canada, which will in fact, for their system, provide one-stop shopping for all disciplines, that is, all users, from all international data sources that can be so organized. Their approach is a one-stop shopping initiative.

The underlying theme of our comments here today has been, of course, the same thing that Dr. Baker mentioned, and that is data access. We believe that it's extremely important as you proceed that some kind of advisory role for industry be included as this EOS Program continues to develop. We have attempted in the GEOSAT Committee, along with others, to work with the Committee on Earth Sciences and OSTP to develop some input for industry cooperative research in earth observations and global change studies.

It is perhaps through such mechanisms or some subset of the PCAST, the Presidential Council Advisors on Science and Technology, that some kind of overriding advisory body, including industry, could be included. Again, I think, in conclusion, our fundamental understanding of the development of these U.S. program systems, EOSDIS, in the United States, EOS in the United States, and related international programs, that these programs will be the fundamental global observation technology for a rapidly expanding resource development and required by our growing population, along with global change understanding and environmental applications.

These will be basically and importantly subject to three basic areas: basic and implied global change studies, government policy and regulatory monitoring, and government and private sector environmental applications. The critical factor will be the extent to which government and private industry efforts can be linked together in the best interest of all in a cooperative program rather than an adversarial environmental confrontation. Thank you.

[The prepared statement of Dr. Henderson follows:]

WRITTEN STATEMENT OF
DR. FREDERICK BRADLEY HENDERSON III
PRESIDENT, THE GEOSAT COMMITTEE, INC.
NORMAN, OKLAHOMA
FOR JOINT HEARINGS OF THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
AND THE
SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION
OF THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
July 24, 1990

Mr. Chairman and members of the Subcommittees:

On behalf of the members of The Geosat Committee and the resource industrial satellite remote sensing user community which we represent, we appreciate the opportunity to testify at your hearings on "International Cooperation in Earth Observing Systems (EOS) Activities" and NASA's efforts to gain international cooperation in the planning and funding of its EOS and EOS-DIS systems to monitor global change. Although we are aware of some of NASA's efforts in these international activities, as members of the private sector industrial user community, we have not been included in NASA's planning, and accordingly, we cannot knowledgeably comment on NASA's efforts regarding international support in planning and funding international EOS systems. We are, in principal, strong supporters of NASA's and other countries' plans for EOS programs to monitor, understand, and develop predictive models for global change. As taxpaying outsiders, excluded from the planning process, we welcome this opportunity to testify and express our concerns with regard to international cooperation while developing EOS programs, and issues relating to international data policy, cooperation, better global change research, and environmental management. The resource industries which support the Geosat Committee are also major factors in producing resources needed by society, and by the nature of our industry we are major contributors to man's impact on the earth's environment. NASA, the U.S. Global Change Research Plan, industry, and the public will benefit from greater international cooperation and participation of both industry and government in the developing EOS and EOS-DIS programs.

OVERVIEW OF INTERNATIONAL EARTH OBSERVATIONS APPLICATIONS, GLOBAL CHANGE RESEARCH, AND ENVIRONMENTAL MANAGEMENT

During the last decade, satellite earth observations coupled with many other global geophysical observations have raised serious concern about man's growing impact on the earth's environment. While this concern is not historically new, modern satellite technology is opening new ways of observing and measuring the earth's environment on an ongoing global basis. What is critically important for this new technology is to assure that it is used wisely to understand natural and man-made environmental changes. Global population growth and demands for improved living standards place great pressures on more resource development and consequent environmental fallout. Therefore, it is vital that the knowledge derived from earth observations and global change studies be prudently applied in international decisions as to which of man's impacts can be corrected and which must be accepted as the price of mankind's continued existence. To accomplish these goals, all of mankind's institutions, including governments, industry, and academia, must work together on the basis of international cooperation, coordination, and contribution.

RESPONSE TO DIRECTED QUESTIONS

In your letter inviting our testimony, you asked us to respond to certain questions. Our responses are presented below.

1. *There is considerable pressure on NASA to increase the international character of space-based global change research (EOS and EOS-DIS). What concerns does increased internationalization raise for U.S. industry? What opportunities does it create?*

Many corporate members of The Geosat Committee and other industrial remote sensing satellite users are international in scope. They are continually confronted with foreign countries' increased emphasis on improved environmental management. In general, we support efforts to encourage NASA to expand the international character of EOS and EOS-DIS systems. Our primary concern is in the area of data policy and in assuring that NASA's efforts to negotiate greater international involvement does not lead to unfair data access between governments and international industrial users.

As NASA expands its international involvement and the differences between U.S. and other countries' institutional relationships between industry and government must be understood. Our concern is that NASA may negotiate EOS data exchange agreements with other countries without ensuring that U.S. industrial access policies are equivalent to those of the other countries. In general, the data access policies of other countries with regard to industrial access are far less restrictive than those of the United States.

For example, NASA has agreed to fly instruments in the Japanese JPOP system after the year 2000 and Japan will fly instruments (ITIR) on EOS-A and later systems. NASA will exchange data with NASDA, but it is not known who else in Japan will have access to the data. The Ministry of

International Trade and Industry (MITI) and JAROS (a government-linked petroleum, mining, and engineering advisory group), play a major role in planning and funding the Japanese JERS-1, ADEOS, and ITIR systems, and will accordingly have direct industrial access to these data. Based on the links between MITI and NASDA, Japanese industry will have access to NASA EOS data exchanged for the Japanese data through NASDA-NASA agreements. However, NASA's developing policy for EOS data does not yet provide for U.S. industry access to the same data. Thus it appears Japanese industry may be allowed to acquire NASA EOS data through NASDA-MITI links while U.S. industry does not have equal access.

Similarly, other countries have mechanisms in place for the sharing of government and industry data. Our concern is that in these countries, industrial users may have access to NASA's data before U.S. industry. U.S. industry will be at a competitive disadvantage to international countries while NASA effectively distributes data through other government agencies. This may be true for ESA, France, and other countries when data and information needed by both industry and government are obtained and distributed to serve both interests under the same system.

I recently conducted a study for NASA's Stennis Space Center entitled "Commercial Objectives, Capabilities, and Opportunities of International Earth Observation Programs, 1990 to 2000" which illustrates the mechanisms for government-industry cooperation in research, development, and uses of satellite data, and how other countries are better organized in this regard than the United States (p. V-3 of Stennis Report). Sections III, IV, and V of the report details these international comparisons and the report has been submitted to the subcommittees' staff for inclusion in the record.

The Geosat Committee urges Congress to provide oversight to help assure that NASA's international agreements will, to the maximum extent possible, insure that industrial data access policy for EOS data will apply fairly and equally to U.S. industry and the industry of the foreign partners, with whom NASA has data exchange agreements.

Regarding potential benefits and opportunities, increasing the international character of the EOS program will allow multinational industrial users of remote sensing to work together on a variety of projects. This will enable a growing international community of industry and government researchers to work on global change and environmental management studies, expanding the opportunity for international data gathering and sharing, and basic cooperative research.

2. *Has there been sufficient industry input into the development of cooperative data policies which may be jointly adopted by NASA, ESA, NASDA, and the Canadian Space Agency? Do adequate processes exist (through international coordinating bodies) to ensure that this takes place in the future?*

There has not been sufficient industry input into the development of cooperative data policies by NASA and no adequate mechanisms are currently being planned for. In recent years, NASA has removed industry participation in the Office of Space Science and Applications (OSSA) advisory committee. NASA effectively has prevented direct industry input into the planning and development of the EOS program. The user industry needs have been ignored. Our concerns about NASA's negative industry users data access policies and lack of industry input were stated in detail in our previous testimony to the Committee on Space Science and Applications on March 1, 1990 (Appended).

Other countries (see reference to Stennis report above) have better mechanisms for industrial input. In France, the CNES Board of Directors includes the Secretaries of all pertinent government agencies, as well as pertinent outside government-industry economic interest groups (EIG). As discussed above, Japan is well served by JAROS and several other industry-oriented advisory bodies. In Canada, the principal remote sensing advisory body, The Canadian Advisory Council for Remote Sensing (CACRS), is chaired by industry.

3. *From the point of view of GEOSAT, has NASA proposed adequate processes for making data from the EOS-DIS available to the user community?*

At present, NASA has not yet proposed adequate processes for making data from the EOS-DIS available to the user community if that refers to the industrial user community. As we understand NASA's current EOS data policy, EOS data will be made broadly available at minimal cost to the science community for basic research in the public domain. As such, NASA's proposed policies should serve the government and academic user communities well. However, the same cannot be said for the industrial user community.

NASA's data access policy does not adequately provide for the requirements of the taxpaying, industrial user community. Our concerns were expressed in detail in the earlier written statement submitted to the Subcommittee on Space Science and Applications in it's NASA hearings on March 1, 1990, as mentioned above. This statement is appended to the current testimony and will not be repeated herein. To our knowledge, NASA has not publicly addressed or ameliorated our concerns since our March 1 statement.

To reiterate our primary concerns, we believe that the NASA EOS data policy is a major improvement for basic science over past restrictive principal investigative practices. However, the NASA EOS data policy does not recognize the inherent need for data access for applied research by industry *before* the industry user wants commercial access for *actual commercial use*. The NASA data access policies as currently stated by NASA (1990 EOS Reference Handbook) and elsewhere do not recognize the inherent confidentiality aspects of industry R&D. While industry must broaden its willingness to publish results, the EOS data policy must include the ability for industry to acquire data for applied research purposes distinct from operational commercial use. Industry should be able to acquire EOS data *for research* purposes as easily as government and academia researchers. Industrial access to EOS data for commercial use should come under a commercial access policy, varieties of which are under review.

Therefore, we recommend that NASA's EOS data policy be developed in terms of three levels of access:

1. Basic science in the public domain
2. Applied science with reasonable publication requirements
3. Commercial access for commercial use

If these three levels require amendments to the Landsat Commercialization act of 1984 to protect NASA's research mission and the remote sensing commercialization experiment for Landsat, the Congress should review this act in light of the importance of *both* the Landsat and EOS programs.

Recent deliberations between the agencies on reaching a commercial data policy to respond to the Committee on Earth Science for the Global Change Research Studies have considered industry applied research data needs. It is not known what the data policy working group will recommend to the CES, but we encourage Congress to review this issue with the CES in order to promote U.S. industry-government cooperation on global change research, earth observations, and better environmental management.

Again, from the point of view of international cooperation, we perceive from the above observations on industry-government mechanisms in other countries that many non-U.S. industrial users will have access to EOS data through their EOS-DIS systems and data policies. This problem of U.S. industry access to EOS data must be resolved if the maximum public and private good is to be realized from both the EOS and Global Change Research Programs in the U.S., as well as internationally.

4. *What will be the process for incorporating data from the EOS instruments of foreign space agencies into EOS-DIS? Will this process also apply to non-EOS instruments that are relevent to global climate research?*

Because the development of the NASA EOS and EOS-DIS programs is further along then similar programs in international partnership countries, we understand that international negotiations have been held and continue with respect to how foreign space agency EOS data and non-EOS data will be incorporated into NASA's EOS-DIS. We understand NASA's intent, as well as that of NOAA as a participant in the U.S. EOS and EOS-DIS programs, is that all international EOS cooperating countries (governments) will have equal access to the entire suite of data from the "international system."

The Geosat Committee supports this goal as long as efforts are made by NASA and others to assure that the developing international data policies treat the question of industry access as equally as possible.

5. *Several participants in GEOSAT are multinational in character. Which entities, including GEOSAT members, are in a position to facilitate "one stop shopping" for end users of data related to global climate change?*

At present, we are not aware of any Geosat multinational members who are in a position to facilitate "one-stop shopping" for end users for data related to global climate change. This service is not presently in place with EROS Data Center nor through any value added firms. In the near future, Radarsat International (RSI) in Canada will be organizing to provide "one-stop shopping" for all disciplines from all international satellite data sources.

What we believe is necessary is for a government or a commercial entity to be organized to serve as a "one stop shopping" place for the information to be extracted from the data. RSI is being organized to provide such information services to the various interdisciplinary needs requirement of industry, academia, and government.

6. *Please elaborate on any other concerns on the international level regarding data access, data ownership, commercial and non-commercial user fees under consideration, and intellectual property rights.*

An underlying theme in our responses to the above questions is assuring NASA's EOS data policy, planning, and implementation have ongoing input from the user industry for both national and international programs, and that such data will be made available to the user community on an equitable basis.

EARTH OBSERVATIONS AND ENVIRONMENTAL MANAGEMENT

Until 1989, most industry applications of future earth observations systems planned for present and future earth observations systems have been in the common areas of agriculture, energy and mineral exploration, engineering, forestry, geology, hydrology, land use management, meteorology, oceanography and related fields. The use of earth observations for environmental applications has been largely on site specific problems within these disciplinary areas. However, the recent thrust of NASA's "Mission to Planet Earth" concept in support of developing their Earth Observation System (EOS), the remarkable media bandwagon, public sensitivity,and political fallout of the satellite demonstrated "ozone hole" and global warming and clean air debates, the development of the U.S. interagency Committee on Earth Sciences (CES) Global Change Research Plan, and the related growth of similar international, cooperating polar-orbiting platform and global research programs, all lead to the general conclusion that the proposed international earth observations systems will become the fundamental global observation technology for rapidly expanding major resource development, global change understanding and environmental applications during the period 1990 - 2010 and beyond (Henderson, 1990, NASA Stennis Report cited above).

The growth potential for the use of earth observations for environmental applications internationally will occur in three main areas as shown in Figure 1. They are (Henderson, op. cit.):

1. Basic and Applied Global Change Studies;
2. Government Policy and Regulatory Monitoring; and
3. Government and Private Sector Environmental Management Applications.

A critical factor in evaluating the social value in expending the large sums of public money needed to support the various EOS satellite systems and the EOSDIS-type ground data management and information systems in the U.S. and internationally will be to determine what roles will be played by the following:

1. Non-commercial government use of earth observations data in the "public good" for global change studies, monitoring and environmental management;
2. Private sector use of earth observations data for resource development, global change studies, monitoring and environmental management; and
3. The extent to which government and private industry efforts above can be linked together in the best interests of all in cooperative programs rather than adversarial environmental confrontation.

SHOWN GRAPHICALLY:

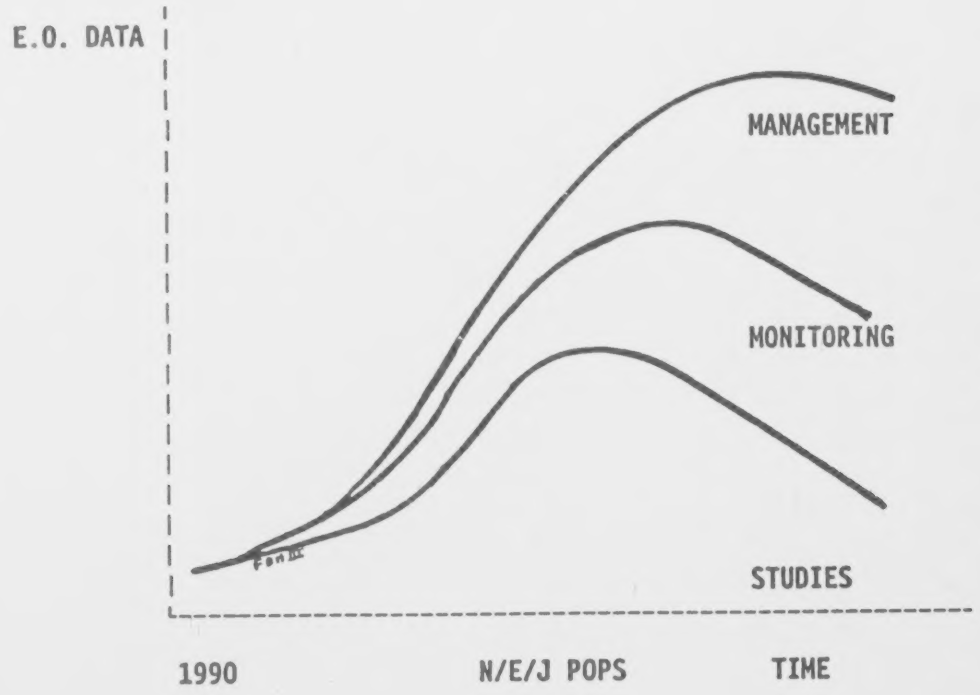

Figure 1

(Henderson, 1990)

Geosat®

**The Geosat
Committee, Inc.**

March 1, 1990

The Honorable Bill Nelson
Chairman, Subcommittee on Space
Science and Applications
Committee on Science, Space,
and Technology
U.S. HOUSE OF REPRESENTATIVES
Suite 2321, Rayburn House Office
Building
Washington, D.C. 20515

Dear Congressman Nelson:

On behalf of The Geosat Committee, Inc., I am pleased to submit, as per your invitation of February 6, our written statement on issues appearing before your committee regarding authorization of the National Aeronautics and Space Administration Fiscal Year 1991 Budget. Our comments pertain to NASA's earth observation programs including "Mission to Planet Earth," the EOS Platform, and the EOSDIS system. We appreciate the opportunity to provide our input into your hearings and stand ready to provide answers to any questions you may have.

Respectfully,

Frederick B. Henderson III

Frederick B. Henderson III, Ph.D.
President

FBHIII:lg
Attachments
cc: Geosat Board of Directors

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Written Statement of
Dr. Frederick Bradley Henderson III
President, The Geosat Committee, Inc.
Norman, Oklahoma
To The Subcommittee On Space Science And Applications
Of The
Committee On Science, Space And Technology

March 1, 1990

Mr. Chairman and Members of the Subcommittee:

On behalf of the members of the Geosat Committee and others in the satellite remote sensing user community, we appreciate the invitation to submit written testimony to your authorization hearings regarding the National Aeronautics and Space Administration fiscal year 1991 budget. While we are a satellite remote sensing user organization who has worked closely with NASA in the past and have been a long term supporter of many NASA programs, we wish to limit our comments in this testimony to authorization issues related to the "Mission to Planet Earth" program in general and to the Earth Observing System (EOS) platform and data management system (EOSDIS) in particular.

SUPPORT FOR THE "MISSION TO PLANET EARTH" AND EOS-EOSDIS PROGRAMS

In general, members of the Geosat Committee and the private sector user community it serves are very supportive of the "Mission to Planet Earth" conceptual program and, in principal, the EOS and EOSDIS programs as we understand them. As geoscientists and engineers, we encourage the use of NASA's space technology to study the earth as a planet from the point of view of an earth science system. Similarly, we also support NASA's development of the EOS platform and data management system as we generally understand them on behalf of the U.S. part of an international effort to study and monitor global change. However, we recognize that the total cost of the EOS-EOSDIS programs will cost $17 billion or more over its expected life time and we are concerned that this expenditure of the public treasury in the difficult years ahead be assured by Congress that it will be expended in the best interests of all segments of U.S. society. This includes basic and applied scientific interests of government, academia, and the private industrial sectors. In this context, Mr. Chairman, we specifically ask that Congress, through your Subcommittee and others as may be appropriate, thoroughly review not only NASA's technical plans for the development of the EOS and EOSDIS programs, but also their operational plans to assure that data and information from these programs is made accessible on a non-discriminatory basis to the U.S. user community in government, academia, and in industry.

If the U.S. government is going to expend these large sums of taxpayer funds to develop advanced earth observations systems, such as EOS, specifically to study and monitor environmental global change and man's impact thereon, then it must assure that U.S. industry can participate in rather than be restricted from such studies through research access to such data in order to encourage government, industry, and academic cooperation in mutually understanding, monitoring and ultimately better managing our environment in the interest of all present and future U.S. citizens.

EOS DATA ACCESS - PROBLEMS AND RECOMMENDATIONS

The Geosat Committee recognizes that the extensive data flow from the EOS-platform sensors presents a major data management and costing problem for NASA. We are familiar with some of data access policy proposals and realize that these issues are currently under review by NASA internal advisory committees as well as the Interagency Working Group on Data Management in Support of Global Change. Listed below are some concerns of the Geosat Committee and other users regarding EOS data access policy issues as we presently understand them. We request that your subcommittee review these issues during the present NASA appropriation process for these programs in order to assure that they will best serve all segments of the U.S. economy.

I. NASA Principal Investigators and other Government Research and Monitoring Users

We understand and support that NASA Principal Investigators, researchers for other U.S. agencies and collaborating foreign government agencies, and personnel in U.S. agency monitoring and regulatory programs will have direct access to EOS data at the cost of reproduction. We applaud NASA's decision to make this data as broadly and as rapidly available as possible to these researchers and to do away with the old restrictions of withholding Principal Investigator data from other researchers. Our only concern in this area is that EOS data exchanged under bilateral NASA agreements with researchers from other government agencies be subject to the same restrictions to foreign private sector users as may apply to the U.S. as discussed below. It should be remembered that in many countries such as ESA, Japan, and France, which are economically competitive with the U.S., that their space agencies have research and technology data exchange agreements with NASA are also intimately interlinked with their own country's private sector industries who are users of earth observations data.

II. Other Individual and Organization Research Users

Users of earth observations data in the Geosat Committee and elsewhere who want to conduct basic and applied research with EOS data would come under this category. NASA requirements for research access to EOS data for this category of research appear to be too restrictive to encourage industry research with EOS data.

A. NASA's restriction that EOS data only be used for fundamental scientific research leading to improved understanding of the earth as a system is too restrictive. While such research should be encouraged in industry, especially in cooperation with government studies of global change, these data should be made available to industry on a research basis for both basic and applied scientific research as their industrial applications may well benefit the U.S. in improving its global economic competitiveness, even if a commercial market for the research oriented EOS never materializes. Certainly, the use of these data in other countries will be applied to economic uses as well as environmental study, monitoring and management. In setting EOS data policy, NASA must clearly recognize that, even under provisions of the Landsat Commercialization Act of 1984, that industrial users need to conduct basic and applied research with EOS data and related data processing systems long before they would seek commercial access to such data for operational commercial uses.

RECOMMENDATION: NASA SHOULD LESSEN THE ABOVE RESTRICTIONS BY BROADENING THE BASIS FOR ACCESS TO TO EOS DATA TO THIS CATEGORY OF USER FOR BOTH BASIC AND APPLIED RESEARCH PURPOSES.

B. NASA is planning to allow research access to EOS data at research prices for this category of user IF the user will abide by rules additional to A. above. These include publishing all results in the open, peer reviewed literature, not redistributing data or derived products to third parties, and providing on request any derived EOS data, information products, and computer processing algorithms and source codes to the public domain, while not using the data in any proprietary manner.

A poll of fourteen Geosat Committee member companies indicates that these restrictions, in particular the latter element, may be sufficiently restrictive to industry users to effectively discourage them from cooperative or other research using EOS data. While industry should be willing to publish THE RESULTS of their research, to expect them to reproduce all ancillary proprietary information to their competitors domestically and internationally in the public domain is institutionally naive.

RECOMMENDATION: NASA SHOULD TEMPER THESE RESTRICTIONS AND REALISTICALLY MEET INDUSTRY HALF WAY TO FIND CONDITIONS UNDER WHICH INDUSTRY RESEARCH CAN BE ENCOURAGED IN SUPPORT OF NASA AND OTHER AGENCIES PROGRAMS TO STUDY AND MONITOR GLOBAL CHANGE. CONGRESS SHOULD ENCOURAGE NASA AND THE INTERAGENCY COMMITTEE ON GLOBAL CHANGE DATA MANAGEMENT TO INCLUDE SIGNIFICANT U.S. USER INDUSTRY PARTICIPATION IN THEIR DATA POLICY FORMATION AND IMPLEMENTATION FOR THE EOS, EODIS, AND GLOBAL CHANGE RESEARCH PROGRAMS VITAL TO THE U.S. LONG TERM INTEREST.

III. Commercial Private Sector and Operational, Non-Research Government Users

NASA is planning to seek a competitively selected commercial vendor to release EOS data to the commercial user community under the block sale provisions of the Landsat Commercialization Act for 1984. While the Geosat Committee strongly endorses commercial access to appropriate EOS data for proprietary commercial uses, we are very concerned about how and when this will be accomplished. NASA's experience with the block sale of Large Format Camera data suggest that this procedure is fraught with procedural and political difficulties and uncertainties. Moreover, the inability of NASA to accomplish block sales or any other reasonable commercial access to Shuttle SAR radar data for more than 5 years, when even the Soviet Union is planning to commercially sell satellite radar data in 1990, further suggests that NASA procedures under the Landsat Act do not adequately serve the tax paying user community in providing reasonable access to such data. If these experiences with NASA under the Landsat Act are valid indications, then the outlook for block sales of the tremendous volume of varied EOS data under the present provisions of the 1984 Landsat Commercialization Act is indeed discouraging! The

Landsat Act was written to provide for the commercialization of the Landsat system and its writers, reviewers, and legislators apparently never fully contemplated the government development of a major, long-term operational experimental program to compete with Landsat in a manner such as the EOS program.

RECOMMENDATIONS: CONGRESS SHOULD REQUIRE NASA TO SET A MORE REALISTIC EOS DATA POLICY TO ENCOURAGE COMMERCIAL ACCESS TO EOS DATA. CONGRESS, NASA, AND OTHER INTERESTED PARTIES MUST REVIEW APPROPRIATE SECTIONS OF THE 1984 LANDSAT ACT TO DETERMINE IF IT SHOULD BE REVISED SO THAT OPTIMAL COMMERCIAL ACCESS TO EOS DATA CAN BE PROVIDED WHILE ADEQUATELY PROTECTING THE BASIC AND VITAL RESEARCH MISSION OF THE EOS PROGRAM ITSELF. IN THE INTERIM, NASA SHOULD ENCOURAGE ITS OWN OFFICE OF COMMERCIALIZATION OR BY OTHER MEANS CREATE AN INTERFACE WITH INDUSTRY AND OTHER USERS TO ENCOURAGE THEIR USE OF EOS AND PRE-EOS RESEARCH DATA THROUGH NON-DISCRIMINATORY ACCESS TO DATA AS PREVIOUSLY STATED IN OUR CONGRESSIONAL TESTIMONY TO THE SENATE AND TO THIS HOUSE SUBCOMMITTEE IN 1985 AND 1986. CONGRESS SHOULD FURTHER REQUIRE NASA TO LESSEN THE RESTRICTIONS ABOVE AND ENCOURAGE GREATER INDUSTRIAL RESEARCH PARTICIPATION IN THE EOS PROGRAM AND IN COOPERATIVE INDUSTRY-GOVERNMENT RESEARCH ON EARTH OBSERVATIONS IN GLOBAL CHANGE STUDIES.

COOPERATIVE INDUSTRY-GOVERNMENT GLOBAL CHANGE RESEARCH AND EOS DATA ACCESS

The Geosat Committee and some other resource companies are working with the Interagency Committee on Earth Science to determine how cooperative industry and government research on the applications of earth observations data can be applied to global change studies to better understand man's impact on the environment and develop better means of cooperative environmental industry-government monitoring and management in the best interests of the nation. To find institutional mechanisms where the U.S. resource industries and government can conduct cooperative research for common environmental problems in a publicly credible manner is difficult at best, but is critical to overall success in this nation's efforts to deal with its growing environmental malaise. Industry can offer to the NASA and other members of the CES research plan, expertise, facilities, resources and abundant ground truth data bases. NASA can provide access to EOS data by means that can encourage industrial cooperation and support for the EOS program.

Mr. Chairman, we seek the interest of your Subcommittee in our endeavors to work with NASA, the CES, and others for cooperative industry-government research in the EOS program for global change studies. We further request that as you review the funding for NASA EOS and EOSDIS programs you do so with consideration to assuring that the EOS data policy will support beneficial cooperative government, academic and industry participation in this expensive and vital U.S. program.

A CRITIQUE OF THE CES
1990 GLOBAL CHANGE RESEARCH PLAN

by

THE GEOSAT COMMITTEE, INC.

February 6, 1990

I. OVERVIEW

The Geosat Committee appreciates the opportunity to have met twice with members of the Committee on Earth Sciences in 1989 to discuss common opportunities for linking industry and government cooperative research in earth observations applications to global change studies. At the December 4, 1989, meeting in Washington, D.C., the Committee on Earth Sciences (CES) asked the industry and academic participants invited by the Geosat Committee to review and critique the 1990 CES Global Change Research Plan (referred here after as the GCRP, or the Plan) as input to the CES's rewriting of the Plan for 1991. This critique is an effort to distill the thoughts of several of the participant reviewers of the GCRP and present them to the CES in the spirit of constructive criticism and support for what we believe is its vital task.

This critique will review and rank the science priorities from the point of view of the participants' industries and offer recommendations. Representative research activities under the science priorities which are of particular interest to the reviewers' companies are discussed. Some management issues and suggestions for the planning review and implementation of the plan are offered. Finally, some gaps or problems in achieving the maximum benefit to be derived from the GCRP for the entire nation are offered as constructive comments from an industry point of view for consideration by the CES.

II. SCIENCE PRIORITIES

For the resource industries, the priorities vary somewhat between non-renewable (oil/gas and minerals) and renewable (agriculture, timber) resources as to major science interests. For the various resource industries throughout the U.S., all GCRP science priorities have some areas of potential research interest.

The oil/gas and minerals (geology) industry seems most interested in Earth Systems History, Solid Earth Processes,

See Data Access
on page 6

Biogeochemical Dynamics, Climate and Hydrologic Systems, and Human Interactions, approximately in that order. Timber and agriculture interests would rank Climate and Hydrologic, Biogeochemical Dynamics, Ecological Systems and Dynamics, and Solar Influences in approximate order of importance.

Recommendations

Establish how linkages will be affected between individual research activities within and between each science priority element. It is not clear how these individual research activities will be prioritized, implemented, and interrelated by individual funding managers under the loose cooperative framework of the CES.

Strengthen the presentation of key science issues as developed in the listing of primary weaknesses. They are more explicitly defined in the weaknesses listing than in the priorities chart or in the following discussion of science priorities and research activities.

III. SELECTED RESEARCH ACTIVITIES OF INTEREST

Most of the reviewers providing input to this critique were impressed with the overall comprehensive nature of the science priorities and research activities contained in the Plan. On first review after the Geosat-CES meeting of December 4, 1989, the Plan seems to have something for everyone. Our initial critique goal of providing a detailed inventory of areas of science priorities and research activities of interest to industry participants will be the subject of the proposed Geosat GCRP Workshop in 1990. The workshop will be held after the 1991 CES GCRP is released later this spring. At this workshop, participants will inventory industry research activities of common interest to those in the 1991 Plan. After identifying areas of research of common interest to government and industry, the workshop will explore how appropriate, industry funded cooperative research initiatives could be established with credible linkages to CES research activities.

The following selected research activities reflect some representative types of potential cooperative industry-government research of interest to some of the Geosat reviewers of the GCRP.

OIL AND GAS INDUSTRY

In the research activity for models linking the impact of energy demands and fossil fuel consumption under priority element "Human Interactions," the energy company members of the Geosat Committee should be in a strong position to contribute to studying the issues of the effects of hydrocarbon usage on our total global environment. These companies have specific data in areas of intense energy activities such as producing fields, pipelines, refineries, petrochemical plants, etc., where they can document both the impact and atmospheric changes and also define many of the remedial and corrective actions already in place.

Some of the questions raised in the priority elements "Biogeochemical Dynamics," "Ecological Systems and Dynamics," and "Earth System History," are relevant to technical issues encountered in oil and gas exploration. For example, the use of bacteria in near surface sediments as an indicator of hydrocarbon microseepage is a new exploration concept. "Designer bacteria" are also being developed as a tool to remedy chemical contamination by drilling operations. More research on these methods is needed and some energy companies might co-sponsor research on bacterial metabolism to evaluate their potential utility in these and related environmental applications.

COAL INDUSTRY

The coal industry is vitally involved in several research activities which bridge the interests of the oil and gas and those of the forestry and agricultural industries. Some of these research interests are:

Biochemical Dynamics:

What are the sources, fate, and relative contributions of greenhouse gases such as CO_2, N_2O, CH_4, etc.?

What are the roles of other fossil fuel consumption related pollutants like SO_2/SO_4, NO_2/NO_3, e.g., the impact of sulfates on the earth's albedo?,

What are the roles of forestation/deforestation in mitigating fossil fuel CO_2 emissions?

Human Interaction:

What is man's role, specifically for fossil fuel use patterns?

Solar Influences:

What is the role that solar variability plays in global warming, regardless of greenhouse gas emissions?

FORESTRY AND AGRICULTURAL INDUSTRIES

Forestry and agriculture companies are interested in many research activities discussed under most of the priority elements. These interests include research in:

Seeking a better understanding of the carbon cycle and the role vegetation plays;

Is the climate really changing and at what rate (a forest crop can take fifty years to harvest time);

Is the ocean rising and how fast (many timber and agricultural lands are near sea level);

Understanding the relation of global tree mortality and changes in air quality and other climate factors (monitored best by satellites?);

Learning what is happening to the world's tree inventory and does it impact climate? (industry might help support a global data base and inventory of forestry resources from satellite data); and

What is the rate and distribution of soil erosion and soil formation in traditional forest and agricultural lands worldwide?

IV. MANAGEMENT ISSUES

Management Success

In reviewing the GCRP, a number of comments were made that deal more with the organization and management of the Plan than with technical issues. Some of these comments are offered here hopefully as constructive criticism. Several reviewers commented that the management issues could far outweigh the technical issues in assessing the potential success of the Plan. Government managers might do well to seek assistance for professional consulting firms in developing a new, fresh approach to organizing and, most importantly, operating a program of this size and complexity. Two levels of success criteria should be established for the program: technical success criteria related to the current accuracy of Earth processes models and anticipated improvements; and, programmatic success criteria describing the impact the program is expected to have on domestic, economic, and foreign policies.

National Advisory Board

There is no limit to the amount of money, either government or industry, that can be spent on GCRP research activities. It is essential that the priorities are set and that forces are mobilized against these priorities to maintain and implement them. This will require a high level national advisory board with the authority to help establish and have oversight for ongoing priorities and programs. To assure optimum benefit to the U.S., the advisory board should have significant representation from industry. In general, the work called for by the GCRP must be done well, or not at all. Poor quality, soft, or incomplete information may not help. Trained government and academic scientists and facilities will be strained to match the goals. In this area, industry can clearly contribute some of the Nation's best scientists and resources.

Methods, Money, and International Contributions

There is concern that the GCRP places too much emphasis on models and too little on the collection of data and experimentation. The budget is undoubtedly too low to accomplish the broader objective of understanding a comprehensive "input/output" model of the earth. In this area, the Plan does not consider the contributions that will be made by other international organizations. In the end, all nations must underwrite and participate in some manner in the GCRP or the international fruits of this awesome task may not impact global environmental decisions as envisioned by the CES. The comments on models in the December 25, 1989 Forbes article by Warren Brooks, pp. 96-102, were noted by several reviewers.

SHARED DATABASE MANAGEMENT

In dealing with the data systems management problems in the plan, a prime objective should be to maximize hardware and software commonality among investigators wherever possible to optimize funds for actual research. While this might appear to some scientists as an encroachment on their creativity, it would produce multiple benefits by saving money and promoting interdisciplinary research through common access to all relevant data sets. Many large international resource companies have significant expertise in this are and could contribute to the CES in design of such user-friendly data and distribution systems.

V. GAPS AND PROBLEMS

Implementation

The GCRP is largely directed towards understanding global change processes, but is not linked to improving implementation methods and technologies for the prevention and amelioration of global change problems. Along with the fact finding, research and modelling, someone needs to coordinate efforts that are necessary to correct the problems that are identified. This will require a global effort. This understanding-implementation gap must be closed or the current, largely academic GCRP exercise will lag government policy and have little productive impact on private industry.

Human Risk

The priorities presented in the current GCRP are based on a very logical and scientific approach to understanding global change. But the CES might reconsider how the priorities would be assigned if they were based on a more quantitative assessment of human risk.

Data Reduction and Public Consumption

Another important gap or problem may be a serious underestimation of the program for data reduction, integration, and reporting. Data gathering and analysis in narrow, focused fields will not suffice. Major mechanisms may be necessary for the cross-correlation of results form historically separate scientific fields. Integrated results will be subject to continued public oversight and will require mechanisms ranging from formal publications and executive summaries to periodic balanced reductions for the popular press to prevent public and government over-reaction to individual issues or interim results.

Industry Input

A major gap in the GCRP is the lack of mechanisms for industrial input. The Program is largely composed of government labs and academia with the attendant risk of loss of objectivity pursuant to the government funding process. Industrial "results oriented" oversight could be an invaluable addition to the Program if mechanisms for publicly credible industry involvement and contribution can be integrated with the Plan.

Data Access

In establishing needed linkages between industry and GCRP research interests, it will be important to broaden industry's normal focus on local environmental issues to include global processes. One key element of industry-government linkage will be to open up means of industry access to government data for cooperative research. In particular, the current NASA conditions for industry access to EOS data for research purposes are restrictive at best, and, if implemented as is, will be counterproductive to joint industry-government research on earth observations applications for global change studies, which could serve to undermine industry involvement with and support of the GCRP.

New Cooperative Research Institutions

Another element needed to further the development of linkages for credible cooperative industry, government, and academic research will be the establishment of new institutional research arrangements between the resource and other industries and government. Such arrangements might be funded institutes such as university cooperative centers of excellence where great interdisciplinary resources can be brought to bear on the "grand convergence" needed to bring together the natural sciences, engineering, social sciences, health sciences, humanities, and policy analysis for government, industry, and academia to study common areas of global change science and issues. Elements that might be considered in establishing a funded cooperative research initiative were provided by the Geosat GCRP reviewers and are listed as the appended "Initiative Element Responses."

Research Before Policy

Finally, the Geosat reviewers expressed concern about the public pressure for government policy decisions before adequate global change study is accomplished or the economic and human impact of such policy decisions are understood. The GCRP identifies three major components of the climate change issues as:

1. Research and understand the earth's environment;
2. Research and develop new technologies to mitigate or adapt to environmental change;
3. Formulate policy changes to respond to a changing world environment.

The reviewers generally believe that understanding the environment should lead to identifying new technology requirements which should allow for formulating policy to respond to a changing environment. While time is important, the main concern that the natural progression from research to policy may be circumvented. This is the case with acid rain issues, where policy decisions are being made prior to the completion of the NAPAP studies or the Clean Coal Technology Program. The GCRP addresses only the first step, the research and understanding of the global environment. Industry is, and government should be, vitally interested in adequate time for research and technology development before or in a sensible interactive manner as policy decisions we must all live with are put into place.

Initiative Element Responses

January 1, 1990

Goals

- Environmental Research - collaboration and communication of results
- Participation in evaluation of alternative solutions
- Generic research in forecasting, prevention, remediation
- Facilitate Industry - government research and education on GCC to understand real changes
- Link R&D with education, economic, societal, policy assessments

Type

- Non-profit
- Joint I/G&A, partnership/association

I-G-A

- I/G&A, (mainly)

Research Program

- Joint venture and individual projects
- Varied Responses

Funding

- I 50%, G 50%

Technology Transfer

- Corporate (and public) participation
- Publications and documentation
- Public meetings

Education

- University research and fellowships
- University Centers of Excellence

Intellectual Property

- No, public domain
- Corporate licensed
- University licensed

Reasons

- Efficiency, economy of scale
- International challenge
- Reduce unnecessary duplication
- Build government - industry (and public) expanded science basis for policy decisions
- Enlarge private sector role in cooperative GCC Research (CBS, GCRP)
- Regulatory threat, cut engineering, legal cost
- Create credible government-industry linkage

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FEBRUARY 6, 1990

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Mr. **Hall**. Thank you, Dr. Henderson.
The chair recognizes Dr. Dutton.

STATEMENT OF DR. JOHN A. DUTTON, COLLEGE OF EARTH AND MINERAL SCIENCES, PENNSYLVANIA STATE UNIVERSITY

Dr. **Dutton**. Thank you very much, Mr. Chairman. I appreciate this opportunity to present my case on the Earth Observing System, especially the international aspects, and I'll make every effort to charge through here and summarize rather than read my comments.

To set the stage, let me say that EOS is important for four reasons. First, it will require the observations we need to advance the science in the understanding of planet Earth; second, it will foster the understanding and the predictive capability we need to address critical policy issues in the years ahead; third, EOS is an important political statement by the participating country that they are concerned about the global environment; and fourth, EOS will be a strong unifying force internationally. All four of these reasons are international reasons.

As you folks know, EOS is much more than a space mission. It is to be an advanced information system that gathers and disseminates information about the earth and its evolution. It's designed to be the sum of three interrelated components. The first component is the EOS Scientific Research Program. This involves interdisciplinary work by many scientists in many countries, much of that is already underway.

The second component is the EOS Data and Information System, which will be a global information network assembling data from the satellites and other sources, making it available to scientists. The third component is the Space Measurement System, which involves the scientific spacecraft to be constructed and launched by the United States and other countries over a 15-year period.

The other witnesses have described the various formal coordination mechanisms that are in place, and I'm going to skip over my own description of that to say more about the Data and Information System. As recognized from the very beginning by the scientists planning EOS, the Data and Information System is the critical component of EOS and the key to the success of the entire endeavor. EOS will be a highly-distributed interactive system that takes the observed data from the spacecraft, converts them into physical data and information, and fosters creative scientific research.

EOSDIS will be a physical communications network, tying together the data sources. It will collect data from other countries, including the many surface observations that will greatly leverage the value of the space observations, and it will make EOS data available to the scientists of those countries.

To be successful, EOS cannot just be built; it must evolve. Thus, it's an important part of the total concept that EOSDIS will start long before EOS spacecraft are launched to make the data we have now from space and other sources available to scientists. We have been creative and generous with resources for acquiring earth science data from space in the surface observation program. Unfortunately, we have been unwisely parsimonious in providing the resources to make that data available so it can be widely used by scientists and students. EOSDIS must start immediately to solve the many problems we have now with access to earth sciences data.

To discuss the EOS data policies, let's note there will be four uses. The first is the development of methods, algorithms and research techniques. The second is application to earth systems science and global change research problems. The third is application to a wide variety of commercial purposes, and the fourth is to educational initiatives in schools, colleges and universities.

I believe that the data policy NASA has formulated for research use of the data is enlightened and wise. Scientists in the EOS partner nations will have access to data for research purposes at the actual marginal cost of filling their request, provided they publish their results in the open literature and make their results available for future use, perhaps by archiving them in EOSDIS.

I think that there is a model here that we should think about. We should make our data available to others and in turn insist on full use of their data for research purposes. The universal access to research data and the sharing of results is critical. The global sharing of weather information by all nations is the model we want to emulate.

With regard to use of data for research, I think that there are broad issues that should be addressed and some recommendations made by the international scientific community with the intent of providing guidance and advice to governments. The International Council of Scientific Unions may be the appropriate body to formulate principles of data access in exchange for the earth sciences, again, building on the world-wide weather information model.

Perhaps in this country we should urge, through the National Academy of Sciences, that ICSU create a global data change commission to develop appropriate recommendations. I might observe that the IGBP Data Office and Working Group now being established in Paris with NASA's assistance is a good first step in this direction.

The use of data for commercial purposes presents more difficult issues, but I believe again that the U.S. policy with respect to weather information is the appropriate model. We should make the U.S. data stream available essentially for marginal communications and administrative costs to firms or organizations that wish to transmit the data to users or intend to provide added value information for commercial purposes. Reciprocal agreements should be sought with other countries, and we should probably examine the possibilities for creating a collaborative international organization or corporation to assemble and disseminate data from all countries for commercial use by all countries.

As a final point about the EOS data and information, I believe there's a tremendous potential for stimulating the interests of young Americans in science and engineering by giving them access to data from space in essentially real time. Space observations of the earth, other planets, and even other stars would be tremendously exciting if they were available on work stations in classrooms throughout the land. School students can do meaningful analyses and studies of such data, and it would make science come alive and be exciting and timely and inspiring to them. It would be an investment with tremendous returns.

Finally, let me say a few words about the EOS Space Measurement System. One family of requirements set by the scientists mandates the use of a large polar platform in order to obtain simultaneous global measurements. The other requirements can be met by smaller spacecraft but perhaps at greater cost.

Now, clearly the troubles with the Hubble Space Telescope will lead some to argue that a large platform is too risky and too likely to have a critical failure. I actually take a different view. I think that Hubble reinforces a lesson that we know very well but tend to ignore. With the Nation's access to space and with individual spacecraft, that lesson is clear. Avoid any possibility of single point failures that will devastate the program or the mission.

The EOS Polar Platform can be designed and constructed as a flexible, resilient, reprogrammable spacecraft with the redundancy necessary to ensure success. We must commit ourselves to that goal. The outstanding successes of Voyager achieved through inflight reconfiguration of key systems demonstrate that it can be done.

Mr. Chairman, thank you very much.

[The prepared statement of Dr. Dutton follows:]

Testimony of John A. Dutton
Committee on Science, Space, and Technology
Subcommittee on Space Science and Applications
Subcommittee on International Scientific Cooperation
July 24, 1990

Mr. Chairman and Members of the Committee:

I am John A. Dutton, Dean of the College of Earth and Mineral Sciences at The Pennsylvania State University. I also serve as a member or chairman of a number of National Academy of Sciences committees concerned with the atmospheric and space sciences and I am the President of the Foundation of the University Corporation for Atmospheric Research. However, today I speak only for myself, as an Earth scientist concerned about global change and about this nation's response to the challenges ahead.

I very much appreciate this opportunity to present my views on the Earth Observing System, especially its international aspects. Because I was a member of two scientific advisory committees that developed the grand plan and overall architecture for EOS, I have maintained an active interest in its plans and prospects.

Let me say first that EOS is very important for four reasons:

1. EOS will acquire the observations we need to advance the science, the understanding, of Planet Earth. EOS is a scientific mission, designed by scientists. NASA has done a commendable job of translating the requirements stated by scientists into specific plans for the mission.

2. EOS will foster the understanding and the predictive capability we need to address critical policy issues in the years ahead.

3. EOS is an important political statement by the participating countries that they are concerned about the global environment and prepared to act responsibly to acquire the information and knowledge necessary to preserve our planetary environment.

4. EOS will be a strong unifying force internationally, bringing scientists of many countries together in a common initiative. The efforts of the scientists will stimulate cooperation by their governments.

As you know, EOS is much more than a space mission. EOS is to be an advanced information system that gathers and disseminates information about the Earth and its evolution, a system that fosters a greatly improved understanding of how the atmosphere, the ocean, the land surface, the cryosphere, and the biological communities on the land and in the sea all interact with each other to shape and control the present and future environment on Earth. EOS is the sum of three interrelated components:

1. The EOS Scientific Research Program. EOS builds upon major international efforts already in progress to understand the climate and the role of the biosphere. The 28 interdisciplinary research centers created by EOS to study specific aspects of the Earth system are already hard at work on studies ranging from the global water cycle and other biogeochemical cycles through the assessment of volcanic effects. Included are detailed studies, by research teams in other countries, of unique regions of the world.

2. The EOS Data and Information System, known by the acronym, EOSDIS. This will be a global information network that assembles data from the EOS satellites and other data sources, including surface instruments around the world, and makes information available to scientists throughout the world.

3. The EOS Space Measurement System, involving scientific spacecraft to be constructed and launched by the United States and other countries over a 15-year period to obtain the first global, comprehensive, and integrated scientific portrait of the Earth and its subsystems.

EOS, in all three components, is an international effort. EOS will be a key part of the ongoing World Climate Research Program (WCRP) organized by the World Meteorological Organization (WMO) and it will be a major component of the International Geosphere Biosphere Program (IGBP) being created by the International Council of Scientific Unions (ICSU). The U.S. Global Change Research Program developed by the federal coordinating Committee on Earth Sciences depends heavily on EOS and provides for the contributions of many federal agencies to these international efforts. The National Academy of Sciences and its Global Change Committee coordinate the United States contributions with those of other nations through ICSU.

The planning and implementation coordination for EOS itself is the responsibility of the International Coordination Working Group, composed of senior officials of the space agencies of the United States, Canada, the European Space Agency and its member countries, and Japan, Brazil, and Australia. The scientific oversight and coordination is provided by the Investigator Working Group (IWG) whose members are the principal investigators on EOS instruments and interdisciplinary teams from this and other countries.

I now want to say more about the EOS Data and Information System, concentrating on its international aspects, and then I will conclude with a few remarks about the space systems.

As recognized from the very beginning by the scientists planning EOS, the Data and Information System is the critical component of EOS and the key to the success of the entire endeavor. EOSDIS will be a highly distributed, interactive system that takes the observed data from the spacecraft, converts them into physical data and information, and fosters creative scientific research by making this information available to scientists and students. EOS investigators and other scientists, in this and other countries, will be able to obtain EOS information from their own workstations. In the United States and in the EOS Investigator Working Group there is a strong emphasis on designing the system from the standpoint of the scientist so that it facilitates progress in science. In some of the other EOS countries, this emphasis has not yet developed, but I expect that it will.

EOSDIS will be a physical communications network, tying together data sources, processing nodes, active data libraries and catalogs, and the scientists' workstations. It will collect data from other countries, including the many surface observations that will greatly leverage the value of the space observations, and it will make EOS data available to the scientists of those countries.

EOSDIS, to be successful, cannot just be built -- it must evolve. Thus it is an important part of the total concept that EOSDIS will start, long before the EOS spacecraft are launched, to make the data we now have from space and other sources readily available to scientists. We have been creative and generous with resources in acquiring Earth science data from space and surface observation programs; unfortunately, we have been unwisely parsimonious in providing the resources to make that data available so it can be widely used by scientists and students. EOSDIS must start immediately to solve the many problems we have now with access to Earth sciences data. An important consequence will be that EOSDIS will encourage scientists and students to become interested in global change problems and to utilize the EOSDIS data resources.

It will take more than hardware and high-speed communications channels to make EOSDIS effective. First, we must develop data standards and formats and interface specifications--this a difficult assignment. Second, we must develop and use new and advanced concepts of data management--an even more difficult task. Third, we must find ways to motivate, train, and reward the cadre of people with talents in both Earth science and information management that are needed now and will be needed in the years ahead. Fourth, we must have internationally uniform data access policies so that the information about the Earth in EOSDIS is complete and includes the data of all countries, so that the information is available to scientists in all countries.

To discuss EOS data policies, let us note that there will be four uses for the Earth information in EOSDIS:

1. Development of methods, algorithms, and research techniques to use and combine space and other data in process studies, in global data summaries, and in new combinations of data and variables;

2. Applications to Earth System Science research problems, including determining the rates of change of key variables, interactions between subsystems, and the development and verification of improved computer models of the Earth system and its components;

3. Application to a wide variety of commercial purposes in resource exploration and management, agriculture, planning, transportation, and other areas;

4. Educational initiatives in the schools, colleges, and universities.

I believe that the data policy NASA has formulated for research use of the data is an enlightened and wise policy: Scientists in the EOS partner nations will have access to the data in EOSDIS for research purposes at only the actual marginal costs of filling the requests, if they publish their results in the open literature and make their results available for further research, perhaps by archiving them in the EOSDIS. NASA intends to make the EOSDIS data available to the scientists of all countries that are openly sharing their Earth science data and contributing to such international efforts as the WCRP and the IGBP. Although there are difficulties because some nations are concerned about sharing data with commercial applications, it appears today that the NASA approach is being accepted by other nations, especially those contributing EOS spacecraft. We should make our data available to others and, in turn, insist on full use of their data for research purposes. This universal access to research data and the sharing of results is critical. The global sharing of weather information by all nations is the model we want to emulate.

While the EOS partner space agencies can develop and negotiate specific data policies among themselves, there are many broad issues that should be addressed and resolved by the international scientific community, in part with the intent of providing guidance and advice to governments. The International Council of Scientific Unions may be the appropriate body to formulate principles of data access and exchange for the Earth sciences -- building upon the world-wide weather information model. Perhaps we should urge, through the National Academy of Sciences, that ICSU create a Global Change Data Commission to develop appropriate recommendations. The IGBP data office and working group now being established in Paris with NASA's assistance is a good first step in this direction.

Use of data for commercial purposes presents more difficult issues, but I believe that U.S. policy with respect to weather information is again the appropriate model. The government should make the U. S. data stream available, essentially for marginal communications and administrative costs, to firms or organizations that wish to transmit the data to users or intend to provide added value information for commercial purposes. Reciprocal agreements to share the data with other countries for commercial purposes should be sought. We should probably examine the possibilities for creating a collaborative, international organization or corporation to assemble and disseminate data from all countries for commercial use by all countries.

As a final point about the EOS data and information, I believe that there is a tremendous potential for stimulating the interests of young Americans in science and engineering by giving them access to data from space -- in essentially real time. Space observations of the Earth, other planets, and other stars would be tremendously exciting if they were available on workstations in classrooms throughout the land. School students can do meaningful analyses and studies of such data and it would make science come alive and be exciting, timely, and inspiring to them. It could be an investment with tremendous returns.

Finally, let me say a few words about the EOS space measurement system. One family of requirements set by the scientists mandates the use of a large polar platform in order to obtain simultaneous observations; other requirements can be met by smaller spacecraft, but perhaps at greater cost. Clearly, the troubles with the Hubble Space Telescope will lead some to argue that a large polar platform is too risky and too likely to have a critical failure. I take a different view. I think that Hubble reinforces a lesson that we know very well, but tend to ignore. With the nation's acc[illegible] to space and with individual spacecraft, the lesson is clear -- avoid any possibility of single-point failures that will devastate the program or the mission. The EOS polar platform can be designed and constructed as a flexible, resilient, reprogrammable space craft with the redundancy necessary to ensure success. We must commit ourselves to that goal. The outstanding successes of Voyager, achieved through in-flight re-configuration of key systems, demonstrate that it can be done.

For the reasons I stated at the beginning of these remarks, EOS is important, to the United States and to other nations. I believe that we must proceed as rapidly as possible to implement EOS -- the research program, the data and information system, and the space measurement system--and we must pursue the goals of EOS vigorously, creatively, and without compromise of the scientific objectives.

Thank you.

Mr. **Hall**. Thank you, and I certainly thank the entire panel for very good presentations, and I guess this is the time in this session to tell you not to judge the interest of the two subcommittees by the participation. The most important people are here or in the crowd or up here somewhere, those who are the staffers that really and truly understand and know what you're talking about and will explain it to us a little more generally later.

But we have from time to time had eight members here, and with the many meetings that we have and things going on, I think that's pretty good. One of the most patient, and he's been in here I think three times, is Congressman John Rhodes from Arizona.

At this time, I'd be glad to yield first to you and let you ask any questions that you might have.

Mr. **Rhodes**. Well, Mr. Chairman, it's true that I've been in and out three times, but, unfortunately, that has basically crippled my capability of having heard enough so that I could ask anything but the most basic of questions, and I agree with you that the information that has been gathered here today is going to have to be reformulated into language that you and I will be better able to understand.

I think that the message I've been hearing is that EOS is going to produce a tremendous volume of data, and it's not quite clear just yet how the data is going to be managed and made available to the various interested segments of the community for various uses.

I did learn a new word, and I'm going to have to have somebody explain to me what this means—megaterabytes.

[Laughter.]

Mr. **Rhodes**. Thank you, Mr. Chairman. I don't have any questions of the panel.

Mr. **Hall**. I thank the gentleman from Arizona.

Following up on some of the statements that Congressman Rhodes said about the data, Dr. Baker and Dr. Tilford mentioned LANDSAT data. Has NASA asked you at the Academy of Sciences to look at what LANDSAT data are needed as part of the EOS data system, and, if so, when do you do this type of review?

Dr. **Baker**. Mr. Chairman, we don't have an official request, but I understand that such a request is coming to the Academy.

Mr. **Hall**. What will be the timing on it so far as you know at this time?

Dr. **Baker**. I can't give you a specific answer, but we expected to see the requests sometime this summer.

Mr. **Hall**. But you know you're going to be asked and you haven't been asked, but you feel like you're pretty sure that you're going to ask you, and if they do ask you, about how long would you think it would be before we get a review?

[Laughter.]

Dr. **Baker**. That's a good question, and since you had three questions preceding it, I'm not sure I can answer that.

Mr. **Hall**. I'll withdraw it if it will help.

Dr **Dutton**. The answer, Mr. Chairman, is you can't sit by the phone all day.

[Laughter.]

Mr. **Hall**. I'll pick on my fellow Texan, Dr. McElroy. The gentleman from Arizona had a word he didn't know what it was. What is SAFISY? I know it's S-A-F-I-S-Y. What does that stand for?

Dr. **McElroy**. That's the Space Agency Forum for the International Space Year, which is the coordinating body to arrange a bit of the scientific celebration in 1992 to celebrate Columbus' 500th anniversary.

Mr. **Hall**. And you've been involved in that, haven't you?

Dr. **McElroy**. Yes, sir, I have. I've been the chairman of one of the two committees which have been working to plan events of various sorts. I happen to be on the one that is looking at earth sciences and technology. There is a second committee looking at educational matters.

Mr. **Hall**. What kind of international cooperation have you achieved? I guess, what are the lessons that we might spread on this record to be learned from that type of cooperation in the Earth Observing System that you've been working on?

Dr. **McElroy**. Actually, the work which has been done under SAFISY is really a direct inheritor of the previous cooperative work that was going on. I don't think we've cut any new furrows in that business at all. I think we've simply taken the existing cooperative mechanisms and applied them to this one specific task.

I think that in that forum we have had representatives of almost 23 different nations who have been participating, our meetings are frequently attended by 14 or 15 nations, so I think it's an indication of the sort of cooperation which will always be there in the earth sciences. The problem that you have with that sort of cooperation, in my view, is that there's no teeth to enforce it. There is good will, there is a moral imperative, if you will, but there is no one really riding herd on it to make sure it happens.

Mr. **Hall**. How would you get those teeth?

Dr. **McElroy**. We've got to have tougher international agreements, I believe, if we're going forward on this program.

Mr. **Hall**. Do you envision those in the future?

Dr. **McElroy**. I hope that they will exist.

Mr. **Hall**. I think you're being a little modest in saying that you just dove-tailed in with what had been done, because my staff tells me that you were one of the main non- Government participants and that you developed the list of 10 research programs or more, went to Italy and sold them, and have some of them operating at this time. Ten of them out of 27 or 28. Is that correct?

Dr. **McElroy**. That is correct, sir. I think, though, the credit is widespread.

Mr. **Hall**. Well, if you were in politics, you would accept that credit. I'm trying to give it you.

[Laughter.]

Mr. **Rhodes**. He's a very modest Texan, Mr. Chairman.

Mr. **Hall**. That's right. Yes, he is. He's probably from Arizona. I mentioned the horns, and the gentleman from Tennessee got up and left a while ago.

Dr. **McElroy**. That's right. Another UT.

Mr. **Hall**. It's a good thing there were no Aggies in the room, I suppose.

[Laughter.]

Mr. **Hall.** Dr. McElroy, you say that firm international agreements are going to be necessary to manage the program. What kind of firm international agreements are you talking about? I'm not asking you to cover the whole area, but just give us some idea of what you're talking about there.

Dr. **McElroy.** I believe that there should be a firm intergovernmental agreement, a signed intergovernmental agreement that commits nations to actually take certain actions. I really believe that when we make this whole pie that it is indeed greater than the sum of the parts, and I would like very much to see Europe committed, us committed, because we're as bad as anyone else on these things, Japan committed, saying that on a particular time we are going to deliver certain data under these conditions and put it right out in front.

One of the things that scares me about the program is that all of us don't live long enough. I first got involved in this program about 1980 or so, so I've been working a decade. I don't have two more decades worth of working life in me. Chances are most of the key players are in the same position. It's going to be handed on from scientist to scientist, engineer to engineer, and we've got to keep continuity in that process. I think that requires firm agreements.

Mr. **Hall.** Dr. Henderson, talk to me a little bit about the danger that this country is going to fund most of the basic research in EOS and that the other nations might develop the applications that will lead to the commercial spin-offs where the money is. Just comment on that some, if you would, your feelings about it.

Dr. **Henderson.** Let me say at first that I think that much of what's being talked about in the EOS data sets, which are rather grandiose, much of that data probably—I question whether or not it would have strong commercial viability anywhere or at any time. I think that there are certain data that will be included or provided through the EOS Program that has certain ultimate commercial value to it. I have no question in my mind about that. I couldn't give you a list specifically which ones will be commercial.

For example, industry will play, I'm sure, a major role in what's to be done about managing the environment in the future in the time frame of the EOS Program. Whether anybody welcomes us at this point, we will be major players, because we are a major contributor to the environmental impact of man, as is everybody breathing in this room.

Our industry is often focused out as a contributor because we're in business rather than worrying about the global management for scientific good of man. I don't think that's true in most of the key people high up in the management of the companies that I've talked to within the GEOSAT Committee. In fact, of the 10 major corporations on my Board of Directors, oil companies, every one of them is committed to having the number one program for the environment in their industry, so there are 10 companies that are going to have the number one program.

I can assure you that their interest is good business, it's prudent, they'll have to do it, but I think most of them — I can, for example, speak to Richard Stigmeyer of Unocal is as environmentally conscientious as a chairman of the board of a major corporation can be, in my experience. However, he, like everybody, realizes this must be done on an economic basis.

Let me point out that most of our industry's interest in EOS data we don't even know at this point in time until we've had a chance to do applied research in many of these things what will have applications that we can use intelligently in better managing our impact on the environment. But there's a broad interest in the access of this data commercially, yes, but also—how do I phrase it except that the environmental use of data for environmental advantagement of industry will be something that's a part of our business equation to stay in business.

Clearly, much of this data in this country and internationally will lead itself to an information service, and we see EOSDIS, for example, we hope EOSDIS will be ultimately available to provide that for commercial services that will take that data and provide information for use by private sector. It may not be in the sense of selling data like we sell LANDSAT or SPOT data today; it will be selling information, not data. But let me assure you the Japanese will understand that.

Mr. HALL. Well, I thank you, and let the record reflect that Lamar Smith, the Congressman from Texas, was in and out of the group, and for fear that he didn't get to ask a question or anything I will note his presence and the chair's appreciation of his presence.

The gentleman from Illinois, Mr. Fawell, is with us, and I will certainly relinquish whatever time you'd like to make any statement you want to make or ask any questions.

Mr. FAWELL. I only apologize for not having been able to get here sooner. I have no questions, but I will be reviewing the testimony. I do have a lot of interest in this area.

Mr. HALL. Thank you.

That pretty well wraps up this hearing, and on behalf of Chairman Nelson and his subcommittee and the International Scientific Cooperation Subcommittee, let me tell you four gentlemen that we appreciate not just the time you've given us today but the time that you have given us in the past and the time in preparation and the travel time and everything. We know it's an imposition on you, and we certainly do thank you and appreciate your time as we do the other three who appeared here. With that, we are adjourned.

[Whereupon, at 3:42 p.m., the subcommittees were adjourned, to reconvene at the call of their respective Chairs.]

APPENDIX

JOI **Joint Oceanographic Institutions**
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September 14, 1990

Bill Nelson, Chairman
Subcommittee on Space Science & Applications
Committee on Science, Space, and Technology
U.S. House of Representatives

Ralph M. Hall, Chairman
Subcommittee on International Scientific Cooperation
Committee on Science, Space, and Technology
U.S. House of Representatives

Dear Congressmen Nelson and Hall:

Thank you for the opportunity to testify to your joint subcommittees on international cooperation in Earth Observing System activities and for your letter of September 6 with two specific questions.

You asked whether the international Committee on Earth Observation Satellites (CEOS) is an appropriate mechanism for coordinating a higher level of shared governance. I believe that the CEOS could do this, if its membership were expanded to include a small number (three or four at most) representatives of these groups that plan major scientific programs. Such groups include the World Meteorological Organization, the International Council of Scientific Unions, and others mentioned in my testimony.

I believe that the CEOS is the right group for coordinating earth observations by satellite because it includes the national and international space agencies that operate the space and ground systems. The participation of these agencies is essential.

You also asked whether NASA had asked the National Academy of Sciences to consider which Landsat data might add value to the EOS data system. The NAS/NRC Panel to review EOS in the context of the U.S. Global Change Research Program, which I chaired, was not asked this specific question. I do not know if any other NAS groups have been asked this question. However, my Panel did note that "current policies that govern the use, distribution, and cost of the Landsat and SPOT data make it difficult for the

• University of California, Scripps Institution of Oceanography • Columbia University, Lamont-Doherty Geological Observatory •
• University of Hawaii, School of Ocean and Earth Science and Technology • University of Miami, Rosenstiel School of Marine and Atmospheric Science •
• Oregon State University, College of Oceanography • University of Rhode Island, Graduate School of Oceanography •
• Texas A&M University, College of Geosciences • University of Texas, Institute for Geophysics •
• University of Washington, College of Ocean and Fishery Sciences • Woods Hole Oceanographic Institution •

research community to take advantage of this resource. When purchased from the commercial remote sensing industry, the data are generally too expensive for most research purposes.

"Current legislation intended to protect the commercialization of Landsat remote sensing activities unfortunately prevents the inclusion of these important data in EOSDIS unless the government purchases the data for that purpose. In our view, Landsat data are sufficiently important to global change research that means should be found to include them in EOSDIS, whether by revising the Land Remote Sensing Commercialization Act, if necessary, or by paying (again) for the data.

"We also believe that it is in the interest of international research to make all environmental data readily available to the global scientific community. Indeed, this is NASA's stated policy in regard to EOSDIS: scientists anywhere in the world with appropriate telecommunications equipment will have access to EOSDIS provided that they adopt the standard research agreement. Only by such a strategy will the usefulness of the data be maximized. Similarly, U.S. scientists should have access to relevant data in foreign archives, and it is important that other nations be encouraged to establish similar data policy assessments.

"Changes in technology and insufficient attention to maintenance of irreplaceable historical datasets currently in various archives threaten to limit their usefulness. In some cases, valuable data may be lost altogether.

"For example, almost all the NOAA 1-km AVHRR data obtained prior to 1986 have essentially become inaccessible because they are still stored in an outdated system. Early Landsat data at the USGS's EROS Data Center in Sioux Falls, South Dakota, and NOAA geosynchronous satellite data at the University of Wisconsin are at risk of being lost forever because their storage media are deteriorating. The success of global change research will depend in part on the availability of a long time series of measurements. The existing archived data are a most important resource in this regard. If lost, they are not replaceable.

"The USGCRP recognizes the need to preserve historical data and includes some funds for the purpose in the FY 1991 budget. We underscore the urgency of moving all relevant data to more secure storage media and incorporating them into the EOSDIS as soon as possible."

Yours sincerely,

D James Baker

D. James Baker
President

PENNSTATE

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The Pennsylvania State University
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September 20, 1990

The Honorable Ralph M. Hall, Chairman
Subcommittee on International
Scientific Cooperation
Committee on Science, Space and Technology
Suite 2321
Rayburn House Office Building
Washington DC 20515

Dear Mr. Hall:

I enclose the transcript of the hearing on July 24, 1990 at which I testified; I have marked a few emendations on the manuscript.

I am also presenting below answers to the two written questions you and Mr. Nelson posed in your letter of September 6 regarding my prepared testimony.

> Question 1, regarding the statement that "U.S. policy with respect to weather information is again the appropriate model" for use of EOS data for commercial purposes.
>
> The streams of national and global weather information and forecast products are made available by the National Weather Service at a port in Washington. There is an annual fee of $10,000 for commercial users; a number of firms subscribe and distribute the data to their clients for various uses.
>
> This model should be adopted for EOS data, perhaps with an appropriate not-for-profit enterprise serving as the intermediary between EOSDIS and the commercial sector. I believe that making the EOS data and other remote sensing data available for a wide variety of applications will have economic benefits of much greater value to the nation than the funds received in an attempt to recover costs.
>
> I believe that data acquired by the federal government for its own research or operational purposes should be made available for all other research, educational, and commercial uses at only the marginal costs of assembling and transmitting it for these purposes. Profits in the commercial sector will be made by adding value to the data and transforming it for specific applications. The public will receive the benefits of more efficient and informed private activities as well as enhanced economic vitality and competitiveness.

Question 2 regarding the creation of a "collaborative, international organization or corporation to assemble and disseminate data for all countries for commercial use by all countries."

The two major advantages to such an organization are that it would make data about the Earth widely available to all users throughout the world and that it would eliminate competition between national or quasi-national entities. Data and information about the earth derived from national and international observational programs supported by governments should be available for all economically beneficial endeavors.

A possible model is that the organization would be funded by making modest charges for use of the data by commercial entities. These charges would cover its costs of operations and the marginal costs of the governments that supply it with data; the organization would reimburse the governments for those marginal costs. Thus users would pay the direct costs of transmitting the data to them, not the developmental and operational costs of the governments obtaining the data. This organization would be subsidiary or parallel to the national and international networks that provide data and information for research and educational purposes; however, it is conceivable that value-added products might be attractive for some research purposes. The basic philosophy is that governments should fully fund the costs of obtaining, processing, analyzing, and transmitting the data needed for responsible scientific research and for education that is in the interests of the public; they should make the data available for all other responsible and socially valuable activities at only marginal costs.

Such an organization would make it possible for the private sector to concentrate on innovative use of the data, on adding value to standard data streams by enhancing their information content through further analysis, and on stimulating informed and efficient economic activity. Not all purposes will be served by such an organization, and there would be opportunities for private corporations, such as EOSAT or SPOT Image, to develop proprietary observational and data analysis systems that meet needs not satisfied by the national and international research data streams.

I appreciated very much the opportunity to testify before your Subcommittee. Please let me know if I can be of further service to you.

Sincerely yours,

John A. Dutton
Dean

Enclosure
dvs

September 12, 1990

Mr. Ralph M. Hall
Subcommittee on International Scientific Cooperation
U.S. House of Representatives
Committee on Science, Space, and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear Congressman Hall:

It was a pleasure to testify before your committee, and I have no changes to submit for the written record. I have attached my responses to your questions on the attached pages. Should you or your committee require any elaboration on these or other questions, I am of course more than willing to do so.

I am very glad to have a fellow Texas in this most important Congressional post. If I can ever be of service, please do not hesitate to ask.

Sincerely yours,

John H. McElroy
Dean of Engineering

Enclosure

Responses to Questions, J. McElroy, page 1

1. In your written testimony of July 24, you recommended establishment of an "independent entity" to subsume the responsibilities of NASA, NOAA, and other agencies, relevant to Mission to Planet Earth.

a. Would you recommend that such an entity be responsible for all global change research activities or only those space-based activities included in the Mission to Planet Earth program?

Answer: In an ideal management setting, all global change research activities would be under a common leadership. However, I recognize that the wide sweep of Mission to Planet Earth likely makes that infeasible. It still seems to me desirable to move in that direction as far as possible. Therefore, my view would be to combine initially the current NASA headquarters activities in the Office of Space Science and Applications with those of the companion headquarters level activities of the National Oceanic and Atmospheric Administration and Environmental Protection Agency. In the latter two instances, my immediate objective would be to separate the research from the regulatory activities (for both NOAA and EPA) and from the industry advocacy activities (for NOAA). I believe that both functions are inherently incompatible with objective scientific research.

The regulatory activities of NOAA, for example, involve the stationing of observers on foreign fishing vessels, the evaluation of seafood quality, and similar functions that are bureaucratic rather than scientific. Similarly, NOAA's home in tha Department of Commerce forces all of its science to be viewed through the perspective of whether or not it contributes to the department's role in enhancing U.S. industry. The science must be approached objectively, and not biased in favor of either environmental or industrial views.

There are other activities within NOAA that could go a number of places, e.g., the mapping and charting function. I do not have an opinion on where that might best be carried out. The Defense Mapping Agency (with appropriate direction) would be one possibility.

Thus, in net, I would place both the space and ground-based global change activities -- at least at the headquarters level -- under the same leadership, and under a common budget element. Whether it is feasible to reorganize or shift laboratories as well, I suspect not. The unification of the leadership is likely sufficient.

b. How would such an entity receive funding if it were not a government agency? Is the Jet Propulsion Laboratory model applicable?

Answer: Following the above line of reasoning, the first step I propose is the creation of unified federal leadership and budget element that permits responsible oversight within both the Executive Branch and Congress. The next step is to evaluate the scattered federal installations that are currently participating in global change research and to examine their adequacy against the plan for the next two or three decades. That scrutiny may show evident deficiencies that should be corrected, or it may not. However, irrespective of what that review says, there is one area in which the creation of a new entity (or the expansion of the responsibilities of an existing entity) seems to me to be vital. That is in the area of the space segment.

In addition to the need to centralize headquarters direction of global change research, I feel that economies of scale dictate that the space segment likewise be under a unified management, as well as those things that are immediately associated with it. Under the current approach, the development of the space segment and the associated research program are located at the third-tier management level within NASA Headquarters, and the project management authority is vested in the third-tier management level of the Goddard Space Flight Center. Both organizations are near or beyond saturation in their capability to provide additional management oversight for a program that dwarfs most scientific endeavors that this nation has undertaken. Further, this is a scientific program that is wholly unlike anything that either organization has undertaken, and it is not clear to me that the experience that has been developed on far simpler, more sharply focused programs is applicable to the Mission to Planet Earth.

In addition, I am not convinced that the Federal Civil Service system can attract the skilled scientific manpower that this task requires. The simple truth of the matter is that the federal scientific and engineering workforce has been savaged by successive administrations who are unable to distinguish between a lackadaisical desk clerk in the Internal Revenue Service and a PhD scientist responsible for a billion dollar a year program. The constant attacks on individuals and the pronounced erosion in the work environment and benefits has crippled the Civil Service's capability to attract high-quality personnel who are committed to a long-term career. People will always be found for two-to-four-to-six year stints, but that does not fit the mold of the Mission to Planet Earth.

Therefore, my view is that it is likely necessary to vest the conduct of the space segment development and the management of the immediately associated global change research tasks in an entity modeled after the Jet Propulsion Laboratory, or one of the other federal laboratories. It cannot be one of the defense laboratories, i.e., Lawrence Livermore, because they have no credibility in this field, they carry too strong a "Cold Warrior" aura, and their motives would be suspect. Therefore, my view is that a civilian, but federally funded, laboratory, with a strong university tie would be the correct vehicle. Thus, just as JPL is funded via NASA Headquarters, the new entity would be funded through the consolidated federal leadership I suggested in the first answer.

This discussion passes by the issue of the current operational land and weather satellites. They play a vital role in future global change research. First, they supply the needed continuing, consistent data upon which the more elaborate research data are overlaid. Second, those spacecraft may provide flight opportunities for research instruments. I believe that the operational data should be provided via a long-term data purchase contract from the private sector. The new federal headquarters entity could be the point of aggregation of those data requirements, or for arranging flight opportunities. The role of the federal establishment should be simplified, and the focus maintained on research leadership, rather than the relatively routine production of operational data.

c. How could classic "turf" battles over the establishment of such an entity be avoided or limited?

Answer: In truth, they cannot be avoided. The Administration would have to provide the leadership that would, for example, overrule the inputs the Secretary of Commerce would receive from subordinates. Easier to say than to do. Holding approval hostage to sensible reorganization is a reasonable strategy.

d. Should such a new entity be the primary contact with foreign global change programs and organizations?

Answer: The consolidated headquarters function should be -- with appropriate oversight.

2. In your written testimony of July 24, you indicated that "it is not sufficient for only informal agreements and coordinating mechanisms to be employed [since] the more ambitious objectives of the Mission to Planet Earth are unattainable in the absence of international contributions." You later recommended "the creation of [an] international earth science coordinating body for the overall oversight" of the entire earth science effort, not just the space segment.

a. Are there any existing international groups that can perform oversight on this broad scope?

Answer: There are the beginnings of such groups in the mechanisms that NASA is employing at present and the International Council of Scientific Unions (ICSU) International Geosphere-Biosphere Program. However, they are not as encompassing as I see to be needed.

b. Are there international groups that might perform such oversight if their membership or responsibilities were augmented?

Answer: Not to my knowledge.

c. Could such an international body succeed without the domestic U.S. reorganization you recommend?

Answer: I do not believe so. There must be a unified U.S. position that is not muddied by differences of opinion of participating agencies, as has happened from time to time between NASA and NOAA, for example.

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Professor Reimar Lüst
Director General

Paris 7 August 1990

Dear Sirs,

Mission to Planet Earth Congressional Hearing

With reference to your letter dated 13 July concerning the information you require for the Congressional Hearing, I have pleasure in enclosing a copy of the policy paper which sets out the "Objectives and Strategy for the Earth Observation Programme of the European Space Agency". It deals with the aims and objectives of ESA's Earth Observation Programmes and stresses the need for international cooperation; it also outlines ESA's role in the coordination of the European contribution.

I also enclose a schedule showing the planned timescales for our major Earth Observation Programmes until the year 2000. They are of course subject to evolution.

Concerning the coordination activities between the international partners in addition to bilateral meetings, ESA participates in a number of formally established forums on Earth Observation matters. An example of this is the Earth Observation International Coordination Working Group (EO-ICWG) set up in May 1986 which is charged with the coordination of a wide range of programmatic issues including payload planning, mission operations, data policy and ground system coordination for the polar platforms. This focusses on the use of the Polar Platforms for Earth Observation and participation is limited to representatives of the Space Station partners. In a wider forum, the Agency also participates in CEOS (Committee on Earth Observation Satellites) and IPOMS (International Polar-Orbiting Meteorological Satellite group). The need for international coordination is a fundamental theme of ESA policy.

In reply to your question on the projected expenditures, I would refer to the European Ministerial Meeting held in The Hague in November 1987, where the Ministers endorsed the proposals for the Agency's overall programme. For the period 1991-2000 the projected expenditure at mid-1986 economic conditions for the overall programme is shown as 25,579 Million Accounting Units (MAU) of which 2,648 MAU is directly related to Earth Observation programmes, i.e. some 10% of the total. The Earth Observation figure does not include the so-called third party programmes such as the Meteosat Operational Programme, which is funded by EUMETSAT and executed by ESA on their behalf. Neither does it cover the First Polar Platform which is included in the Columbus Space Station budget, nor the funding which is included under our General Studies Programme and our Technological Research Programme, etc.

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The ESA Earth Observation estimated expenditure costs over the period 1991-2000 can be summarised as follows:

	Accounting Units at 1986 economic conditions
- Earth Observation Programmes	2 648
- First Polar Platform	622
- Earth Observation studies and technological research	65
- Meteosat Operational Programme (on behalf of EUMETSAT)	105
	3 440 MAU

This figure at today's price levels can be equated to say 4.000 m$.

A direct comparison between the NASA projected expenditures and those of ESA would be misleading in as much that in ESA we are concerned mainly with the spacecraft and with the initial data processing and not with the research into using the data or its exploitation. Furthermore the majority of the Earth Observation Announcement of Opportunity Instruments are funded separately by outside institutions and therefore are not included in the cost projections.

Another good example of cooperation is the current consideration being investigated jointly by NASA and ESA to build a dedicated Solid Earth mission (ARISTOTELES) the data from which is expected to provide information fundamental to many global change monitoring investigations from space.

Concerning other projects undertaken in Europe outside the responsibility of the Agency there are several projects of this kind, for example, there is the French SPOT Programme, the French TOPEX-POSEIDON Programme (jointly with NASA) and the German/Italian X-SAR. However, we are not in a position to give the cost figures for individual Member States earth observation related activities which are conducted outside the framework of ESA.

Regarding the ESA policy for data access this is under continuing discussion with our international partners, for example, as mentioned earlier, the EO-ICWG is charged with coordinating the data policy for the Polar Platform and this is an ongoing exercise.

In the short time available, it is not possible to provide detailed answers to your specific questions but I trust this general approach will assist in your deliberations.

Yours faithfully,

Reimar Lüst
Director General

Mr Bill Nelson
Chairman
Subcommittee on Space Science
and Application
US House of Representatives
Committee on Science, Space
and Technology
Suite 2321 Rayburn House Office Building
Washington DC 20515

Mr Ralph M. Hall
Chairman
Subcommittee on International
Scientific Cooperation

ESA Earth Observation Long-Term Planning

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Schedule of Approved and Future Missions

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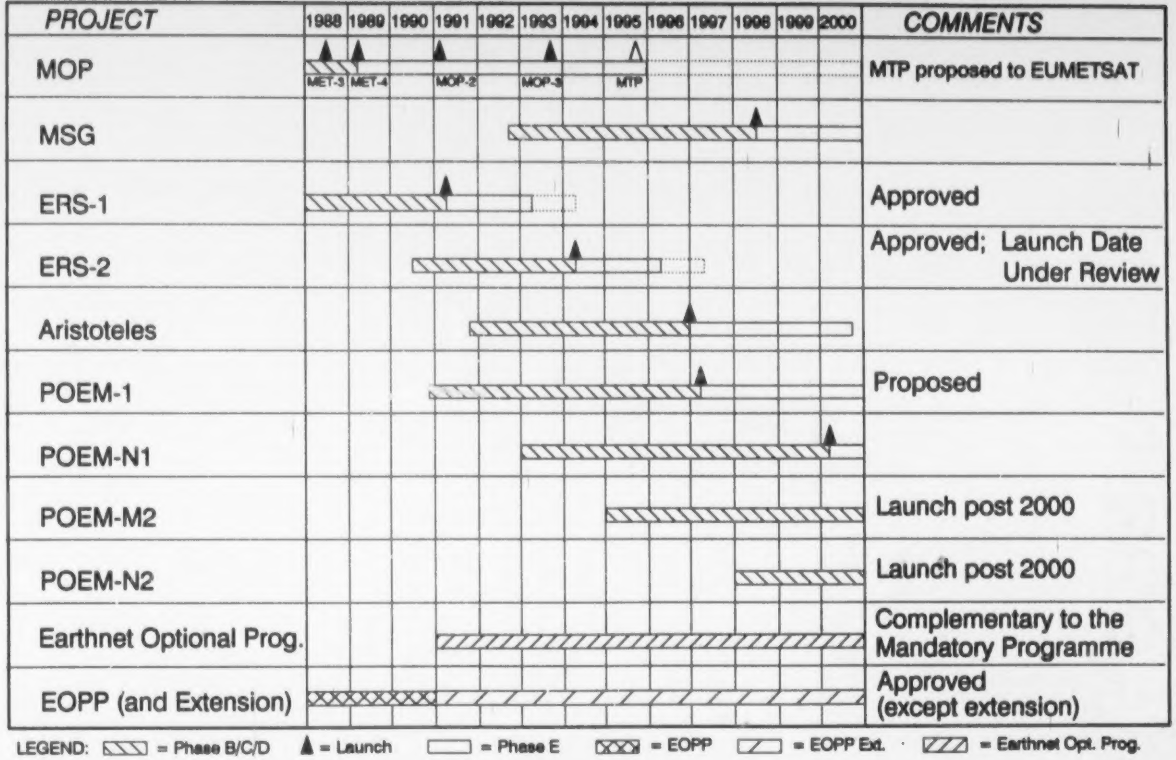

esa

October 1988

OBJECTIVES AND STRATEGY

for the

EARTH-OBSERVATION PROGRAMME

of the

european space agency

DIRECTORATE OF
EARTH OBSERVATION AND MICROGRAVITY

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PREFACE

The observation of the Earth has been part of the Agency's programmes since the advent of the meteorological satellites of the Meteosat Programme more than a decade ago. Their images have contributed to provide mankind with a new global perspective of his environment. In the meantime, the techniques of remote-sensing of the Earth from space have evolved to the point where they can be exploited to achieve an understanding of how the Earth's components function as an integrated system (atmosphere, global oceans, land and ice areas, internal structure of the globe and its dynamics, etc.).

The growing awareness of the need to see the Earth as one system, if we are to solve the major environmental problems presently facing mankind, is fundamental to the success of a future Earth-Observation Programme.

"We need to establish a realistic and affordable overall strategy in Earth observation".

Recent events, in particular the instructions given by Council at its last meeting in June 1988, and the overall situation of the ESA Earth-Observation Programme, have induced the Earth-Observation Directorate to re-examine its objectives and strategy for the longer term (up to and beyond the year 2000).

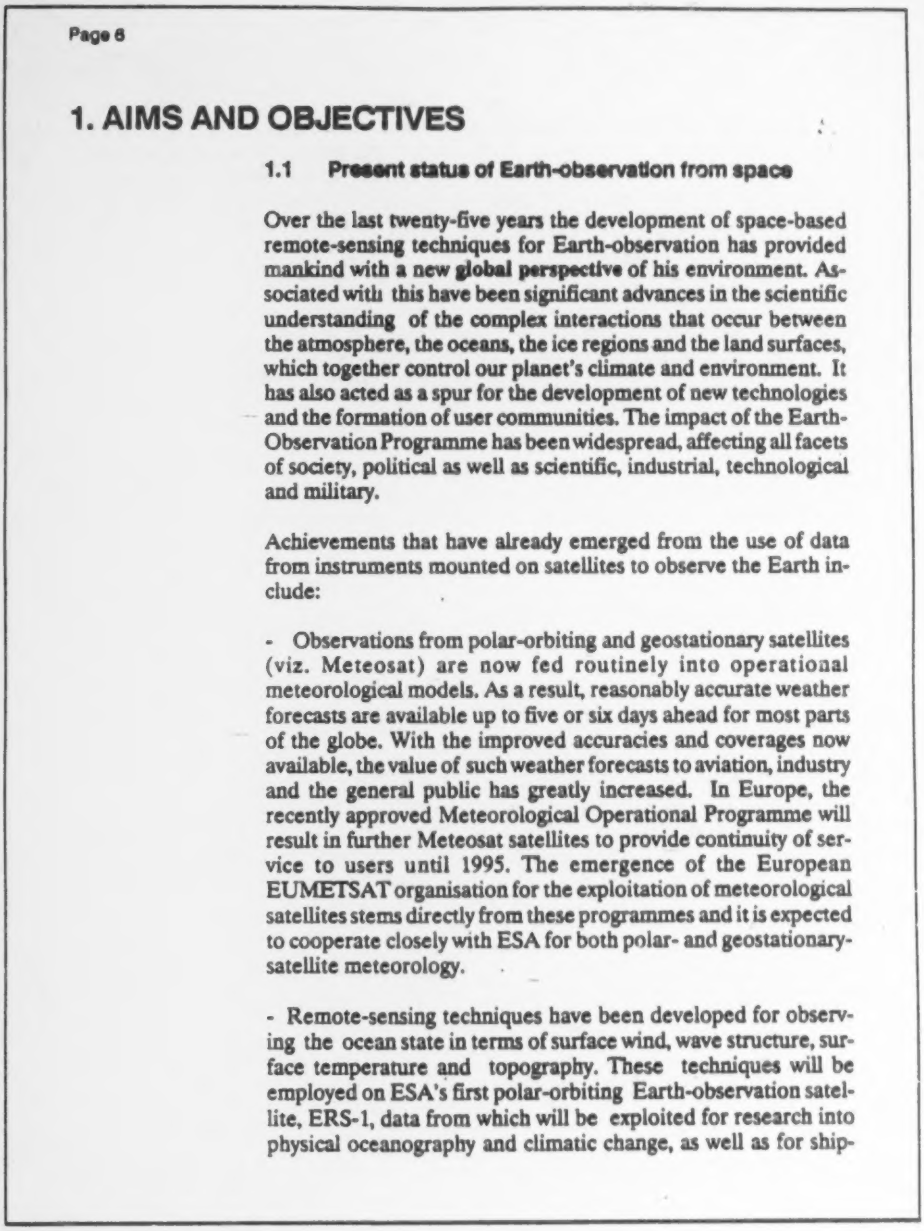
This strategy must embrace the global aspects of such a programme, and has to be established in the context of the programmes of other space agencies and in worldwide cooperation with them. Europe has the opportunity over the next two decades to play a leading role in this domain.

"The time is now right to formulate such a strategy and to recommend those elements that could implement it."

This document addresses in detail the investigations needed for each component of the entire Earth system, reviews the various problems and opportunities and proposes a long-term strategy that would best fulfil the overall objectives and aims. It also attempts to outline the steps required to put this strategic approach onto an operational footing, and in particular the elements that should constitute an Earth-observation Programme commensurate with these objectives.

The document is therefore directed not only to the scientific research community, but equally to potential user entities and to government authorities who eventually have to assume due responsibility for the monitoring and management of our environmental and planetary resources.

In following the proposed strategy, Europe will not only contribute to the solution of major problems relevant to the future habitability of the Earth but has the chance to take a leading role in its accomplishment.



1. AIMS AND OBJECTIVES

1.1 Present status of Earth-observation from space

Over the last twenty-five years the development of space-based remote-sensing techniques for Earth-observation has provided mankind with a new **global perspective** of his environment. Associated with this have been significant advances in the scientific understanding of the complex interactions that occur between the atmosphere, the oceans, the ice regions and the land surfaces, which together control our planet's climate and environment. It has also acted as a spur for the development of new technologies and the formation of user communities. The impact of the Earth-Observation Programme has been widespread, affecting all facets of society, political as well as scientific, industrial, technological and military.

Achievements that have already emerged from the use of data from instruments mounted on satellites to observe the Earth include:

- Observations from polar-orbiting and geostationary satellites (viz. Meteosat) are now fed routinely into operational meteorological models. As a result, reasonably accurate weather forecasts are available up to five or six days ahead for most parts of the globe. With the improved accuracies and coverages now available, the value of such weather forecasts to aviation, industry and the general public has greatly increased. In Europe, the recently approved Meteorological Operational Programme will result in further Meteosat satellites to provide continuity of service to users until 1995. The emergence of the European EUMETSAT organisation for the exploitation of meteorological satellites stems directly from these programmes and it is expected to cooperate closely with ESA for both polar- and geostationary-satellite meteorology.

- Remote-sensing techniques have been developed for observing the ocean state in terms of surface wind, wave structure, surface temperature and topography. These techniques will be employed on ESA's first polar-orbiting Earth-observation satellite, ERS-1, data from which will be exploited for research into physical oceanography and climatic change, as well as for shipping, commerce, the offshore industry and many other applications.

- Remote sensing of land from space (Landsat, SPOT, and meteorological satellites) over a range of visible and infrared spectral wavelengths is being applied to fields as diverse as vegetation monitoring, agriculture, forestry, geology, hydrology, land use, cartography and glaciology, for a variety of scientific research activities and applications.

- Accurate satellite tracking has led to vastly improved knowledge of the shape of the Earth and its gravity field. Apart from the scientific importance of such data, it has already found wide application for navigation.

- Global measurements of the structure and composition of the middle atmosphere from space have led to greater understanding of the interplay between radiation, chemistry and dynamics there. They have assisted greatly in the assessment of the influence of man's activities on the ozone layer, the greenhouse effect, etc.

None of this would have been possible without the **global and regular coverage** provided by satellites (in both polar and geostationary orbits), together with the extraordinary developments in computer capabilities which have allowed the development of more and more sophisticated models and interpretation techniques.

This initial experience has led increasingly to acknowledgment of the fact that the major environmental problems are global in nature. With this realisation goes the acceptance that the role of Earth-observation from space will be fundamental to mankind's search for viable solutions based on a comprehensive understanding of the total Earth system.

1.2 Rationale for the future European programme

The rationale for the future European programme in Earth-observation is founded on the acceptance that major problems, which are just being recognised, concerned with the well-being of mankind on an Earth, with limited resources and with increasing demands on those resources, can only be addressed effectively if we understand the complexities of the global Earth system to a much greater degree than at present. Better basic observations are fundamental to this requirement.

Thus the future Earth-observation programme must address not only the environmental issues themselves, but also the management and monitoring of both renewable and non-renewable resources, the needs of operational meteorology, problems associated with the solid Earth and, most importantly, the interactions between all of these areas.

This calls for :

1. The development and application of new active and passive visible, infrared and microwave techniques in order to :

(a) improve atmospheric observations for weather forecasting, climate research, pollution transport, etc.;

(b) provide better observations of the distribution of minor constituents in the lower and middle atmosphere, since they play a vital role in assessing the effect of man's activities on crucial geobiochemical cycles such as those of nitrogen, sulphur and carbon;

(c) enhance global observations of the structure of the ocean surface and its ice fields for marine applications, coastal pollution studies and climate research;

(d) provide continuous monitoring of the solar spectrum with carefully calibrated instrumentation;

(e) extend the operational applications of land observations.

2. The further development of those systems aimed at observing the global-regional aspects of the solid Earth that can best be made from space.

3. The development of suitable space platforms on which to fly the new instruments in the most cost-effective manner.

4. The enhancement of the ground segment to ensure that the data are made available to the users in the best format and in a timely manner.

5. The acceptance that, for most applications, there is a need for continuity over a time span of at least a decade, and that the payloads needed are basically multidisciplinary in that their output can contribute to more than one of the user-problem areas.

6. The further development within the various scientific, application and operational user areas of appropriate numerical models, with suitable data-assimilation techniques, to exploit the new data from space in the most effective way.

7. The continuity of fundamental research in Member States in order to further improve the impact of space data with application, operational and ultimately commercial user requirements firmly in mind.

8.International cooperation to ensure that the European endeavour is consistent with the global-scale of the overall requirements.

1.3 Need for international cooperation and ESA's role

In the 1970's, the emphasis was on demonstration of the feasibility of adequate measurements from space. Events such as Chernobyl, the identification of the hole in the ozone layer, the daily evidence of air pollution in towns, of water pollution in rivers, lakes and coastal waters, the loss of a large portion of the World's forests in developing countries due to uncontrolled deforestation and in industrial countries due to acid rain, fire and infestation, and the progression of desertification in all continents, have given the public, the media and political circles a new awareness of the effects of anthropogenic pressure on the environment. Consequently, a wide consensus is emerging that such issues are not confined to the local or national level, and that a broader international initiative is needed, firstly to understand the critical issues better, and secondly to initiate corrective actions.

Availability of better and more organised information about natural resources and environmental variables is crucial, in order to provide a firm platform of knowledge on which future political and international initiatives regarding the environment on a planetary scale can be based. Earth-observation from space can contribute substantially, and in many cases uniquely, to the building of this information system. The development and operation of space systems capable of detailed monitoring on a global scale must be regarded as an essential prerequisite for any truly serious attempt to conserve and eventually manage our planetary environment.

Responding to this challenge implies the starting of long-term fundamental and applied research programmes, aimed at a better understanding of our planet, and coordinated at national and international level. In parallel, ad hoc national and international initiatives should focus on the monitoring, control and forecasting of changes in specific elements of our environment, and on how to counter any deteriorative trends. The entities and organisations in charge of environmental monitoring at regional and national level will also need infrastructures capable of exploiting the data provided by spaceborne Earth-observing systems.

Global Earth-observation and monitoring is truly an international endeavour. ESA's role in coordinating the European contribution to this international enterprise is to build upon the sound foundation it has already laid to provide the space-based technology systems that will be needed.

2.USER ASPECTS

2.1 Background

Progress in the geophysical sciences is essential to the understanding of our planet, in terms of timely knowledge of climatological, meteorological, oceanographic, geological and environmental factors. Progress in a number of these fields has been very slow, if not impossible, in the past due to the absence of adequate global, repetitive, synoptical, and accurate measurements. As an example, the growing availability of meteorological satellite data over the past 25 years, linked with the development of large computers, has played a major role in the spectacular advance of meteorology and operational weather forecasting. This progress has also produced important spin-offs in the application of meteorological data for air-traffic control, sea-state forecasts, offshore operations, agriculture, etc.

Remote-sensing data have been available in various forms for about 15 years, initially from aerial photography and later with the emergence of digital image techniques, from spaceborne instruments. These data have permitted studies of land, ocean and ice processes to different degrees : in some cases they have led to the creation of "operational" or "commercial" systems, such as SPOT or the later Landsats. With their innovative payloads (primarily microwave sensors), ERS-1 and the French-American TOPEX-POSEIDON satellites will allow substantial progress in the areas of ocean and ice studies and will also hopefully lead to operational systems.

The growing interest in remote-sensing in Europe, particularly in the scientific community, is already being reflected in:

- the growth of the European Association of remote-sensing Laboratories (EARSeL) over the past ten years, from the initial 10-20 to about 250 now;
- the number of remote-sensing courses at Universities;
- the growth of remote-sensing research laboratories in industry and in the public domain at regional, national and local level;

- the increasing number of remote-sensing congresses, symposia, colloquia, seminars, etc. being held;

- the exponential growth in the number of publications covering the scientific (more) and application (less) aspects of remote-sensing ;

- the increased demand for workshops and training courses on remote-sensing and its applications;

- the increasing space devoted in the media to environmental matters with space connotations.

2.2 Diversity of user requirements

The Earth-observation user community embraces a wide spectrum of individual groups whose interests may be broadly classified into the following disciplines:

- Atmosphere
- Ocean
- Ice
- Land
- Solid Earth.

The number of topics falling under each of these broad headings is very large. In the case of Atmosphere, for example, it includes meteorologists and climatologists but, in addition, it encompasses the different types of atmospheric scientists, such as dynamicists, chemists, etc. Generally, these groups include research scientists as well as those concerned with the actual provision and use of data for operational purposes.

Similarly, such topics as climate, or the geo-biochemical cycles involve all of these fields.

Also the various domains often have contrasting requirements, in terms of sensor characteristics, spatial and temporal observation requirements, etc. Conversely, an individual sensor often serves several disciplines or application domains, but perhaps to different degrees, while some scientific or application domains require contributions from several spaceborne instruments.

Geology, for example, usually requires a single coverage or at most a few coverages spread over different seasons, in order to account for the masking by vegetation of the morphological features of interest, relying on a combination of instruments operating in the visible and microwave parts of the spectrum. Cartography, on the other hand, requires regular updates as the territory of interest evolves.

Monitoring of forested areas (extent, status, health), due to the external events that may affect them (authorised and non-authorised deforestation, fire, plagues, acid rain, drought, landslides, avalanches), requires at least two observations per year, with instruments operating in the visible, infrared and microwave ranges.

Monitoring of agricultural crops and environmental factors, management of water resources, including ice and snow melt, and water run-off forecasting, all require more frequent observations, ranging from once a month to once or twice per week during specific seasons, with different instrument classes. Finally, weather forecasting, operational sea-ice monitoring, fishery support, and ship-traffic monitoring require continuous availability of data and real-time delivery.

These examples help to highlight the difficulties encountered in defining mission scenarios and payloads when it is attempted to combine several disciplines, compromising on the characteristics and requirements of each. A combined suite of geostationary, polar and specific-to-mission satellites is needed to address all the areas of global concern.

2.3 Categories of users

The user community includes:

- The scientific-academic sector composed of universities-laboratories-institutes.

The scientists are generally well-organised in their individual fields and try, more and more frequently, to coordinate their research within large-scale programmes. Depending on the nature of their research activity, their data requirements range from limited sets to global long-term series.

- The application sector, composed of:

.Intergovernmental entities such as EEC, FAO, etc.

. Government entities such as Meteorological offices, Hydrological services...

. Ministerial departments for agriculture, fisheries,land use, regional development, environmental monitoring, etc.

. The private sector (mining and oil companies, value added services, etc.).

The application sector, often referred to as the "remote-sensing (potential) market", includes more specifically:

. Individual users and small to medium sized user entities (in terms of data quantities required), with their own know-how and ability to use, process and interpret remote-sensing data. This segment of the "market"is growing slowly, mainly in such areas as cartography, topography,geology, oil exploration, etc.

. Large organisations, which increasingly include governmental departments concerned with environmental problems, responsible for or involved in continuous, operational, large-scale applications. These organisations, with the exception of the meteorological bodies, are often not yet fully aware of the potential contributions of remote-sensing technology to their applications.

."Value added" industry: this term originally identified a layer of companies (mainly small), who intended to acquire data from the satellite operators, manipulate and interpret them according to end-user requirements, and then re-sell the results to the user. The increasing awareness, know-how, and data-handling capabilities of end users, in particular of large organisations, which tend to interface directly with the satellite operator, are forcing this segment to evolve more and more towards a consultancy role, in support of these end users, rather than constituting a "direct" consumer of remote-sensing data.

The application community, with the exception of meteorological organisations, is considerably less organised than the scientific community. Conversely, their data requirements, once identified, are very large, span long time periods, and cover regional to planetary geographical scales. The objectives and the spatial and temporal dimensions of their activities justify the investements required in order to adopt remote-sensing technology as an essential contribution to their data gathering process.

2.4 Involvement of the user community

Given the diverse nature of the user community and to avoid Earth-observation programmes being primarily technology-driven, it has always been the Agency's policy to involve users in all stages of mission definition, satellite and instrument development, and data exploitation. They are involved in the definition of the system (space and ground segments) through calls for ideas, calls for instrument proposals, instrument working groups, workshops and study contracts on specific matters related to sensors, data algorithms, calibration, etc. During the system's exploitation phase they participate in such processes as the setting up of pilot projects, demonstration experiments, etc. The Agency also makes special efforts in the fields of training and education .

Historically, the main involvement has been that of the scientific community. This means that ESA and other satellite operators are still trying to assess the long-term operational, and eventually "commercial", potential of instruments conceived mainly by scientists to improve basic scientific understanding, and not as long-term tools to support operational activities. Again, the major exception is meteorology, the reasons and background for which merit careful study.

This community already makes regular and large-scale (global) use of the data from satellites and this usage will undoubtedly continue to increase. Its requirements are well identified, constant in time, or evolve at a reasonably slow pace; the community is well organised and has strong political support, with its channels for identification and submission of requirements to the space agencies well defined.

Other user groups, such as the land community, are generally not as developed and need to be brought up to the same level of involvement and organisation as the meteorologists. This can be done only by involving large organisations that have the resources to undertake the learning process, and the critical size that justifies the adoption of an initially expensive technology such as remote sensing. The Earth-observation community will always exhibit wide variations in the maturity of its data requirements and in the patterns of data usage, and this must be taken into account at the planning stage.

However, it cannot be over-emphasised that solutions to the major environmental problems is a governmental responsibility and in this sense ESA's Earth-observation programme must directly meet the needs of the Governments of the Member States.

A brief overview of user-community-oriented activities undertaken to date is provided in Annex I.

3. SPECIFIC INVESTIGATIONS

3.1 Introduction

It is now widely accepted that many of the major challenges facing mankind today are related to environmental issues and it is becoming increasingly clear that many of man's activities are starting to affect his environment. Five of the most prominent examples are:

(a) The atmospheric warming due to increases in "greenhouse" gases such as carbon dioxide.

(b) The catalytic destruction of stratospheric ozone (viz the "ozone hole") by chlorofluorocarbons.

(c) Increased acid deposition ("acid rain"), resulting in damage to lakes, soil, etc.

(d) Increased photochemical oxidant formation which causes damage to plants and forests.

(e) Land erosion, deforestation, etc. which affect the ecological balance.

Recent statements by Germany's Chancellor Kohl and Britain's Prime Minister Mrs. Thatcher reflect the growing concern of the World's leading politicians. This places a great responsibility on the whole geophysical community, to whom society will look for answers. The response to this challenge must be reflected in ESA's programme for Earth observation. The interests of this community and their relevance to the challenges facing mankind is the concern of this chapter.

The fact that the geophysical community embraces a very wide spectrum of interests means that lines of demarcation are not clean cut and the work relevant to large programmes like the International Geosphere-Biosphere Programme (IGBP) or the World Climate Programme (WCP), tends to be dispersed between the different disciplines. To make it easier to assess the importance/relevance of Earth observation to specific interdisciplinary programmes, four inter-related themes will be pursued here, namely: environment, resource management, operational meteorology and solid Earth.

3.2 Environmental problems - climatic change

There is increasing concern that man's activities are starting to affect the sensitive thermodynamic and ecological balance of our planet. The increase in the atmosphere's carbon dioxide concentrations due to the burning of fossil fuel and deforestation is probably the most crucial. It has been predicted that mean global temperatures may rise by as much as two to three degrees Celsius over the next fifty years, with possibly twice this increase at higher latitudes. This warming is comparable in magnitude to the change from the last ice age to the present climate and will be accompanied by major shifts in regional rainfall and vegetation patterns. It could also lead to a partial melting of the polar ice caps. Large areas that are today densely populated could be inundated.

The magnitude and rate of change of these processes cannot yet be reliably measured, let alone predicted. Furthermore, they are difficult to detect in their initial stages because the weak trends tend to be masked by natural climate variability. Continuous monitoring of climatic variables, particularly such sensitive indicators as mean sea level and the heights of the ice caps, is therefore essential to obtain the earliest possible warning of progressive or sudden change. However, because of the complexity of the system and the many different ways in which man's activities can affect environment and climate, the monitoring programme must cover all the essential components of the system, including the atmosphere, oceans, ice regions, land surfaces and biochemical cycles. Both global and continuous observations are needed to resolve the broad range of space and time scales involved in the prevailing climatic and environmental variations. It was recognition of the many facets of the challenge that led to the formulation of the International Geosphere-Biosphere Programme (IGBP).

Monitoring changes is only part of the challenge. Difficult though this is in itself, to meet the needs of mankind it is also necessary to develop a proper understanding of climate in order to detect and predict climatic change and assess man's role in inducing such change. These are the specific goals the World Climate Programme (WCP), and meeting them is one of the major challenges now facing mankind.

The needs of this area really encompasses those of all the others. The detection of climatic change will require long-term records of variables. Developing an understanding of climate requires studies of global phenomena (viz. the hole in the ozone layer, the El Nino, etc.), but in addition it is necessary to study much smaller scale phenomena if an understanding of underlying mechanisms is to be developed.
The requirements are therefore wide ranging, with a bias towards global scales and a need for continuity of data over periods of a decade or more. The role of Earth observation from space is therefore fundamental to success as without it little progress will be possible.

Atmosphere and Climate - The atmosphere is a very complex machine and knowledge is lacking in many areas, such as radiative processes, ocean-atmosphere coupling, interactions between the atmosphere and the land-ice surface, and the formation and evolution of clouds. There are also large gaps in our understanding of the chemical processes that occur in the atmosphere.

The primary need is for data to be input into models, so that theoretical understanding can progress. These data are also needed to monitor the state of the atmosphere in order to highlight changes, such as the ozone anomaly detected over the Antarctic.

Some appreciation of the extent of this requirement is provided by the latest initiative to emerge from the World Climate Research Programme, namely the Global Energy and Water Cycle EXperiment (GEWEX). This recognises that at present it is impossible to balance either water or energy cycles except in a few specific instances. It seeks to redress the balance by capitalising on future spaceborne systems (to be used in conjunction with the current observing network). The requirements, summarised in Table 1, are very wide ranging, extending into areas not traditionally associated with meteorology or the atmospheric sciences. Meeting many of them will pose major challenges.

TABLE 1

DATA REQUIREMENTS FOR EARTH OBSERVATION

1. Radiation and Clouds
-Solar irradiance
-Reflected solar flux at top of the atmosphere
-Emitted infrared flux at top of the atmosphere
-Incident solar flux at the surface
-Downward long-wave radiation flux at the surface
-Net flux at the surface
-Trace gases and aerosols (CO2, N2O, CH4, O3, stratospheric water, aerosols)
-Cloud amount, type, heights of bases and tops
2. Standard Atmospheric Variables
-Surface meteorological observations (land, sea)
-Temperature profiles
-Tropospheric water vapour
-Upper air winds
3. Precipitation
4. Ocean Surface Variables
-Sea surface temperature and wind
-Ocean mixed layer thickness and heat storage
-Sea-ice extent, type and motion
5. Land Surface
i) Land-surface properties
-Surface albedo and roughness
-Surface skin temperature
-Surface emissivity
-Vegetation index
ii)Boundary layer variables
- Wind, temperature, water vapour content
- Temperature and humidity profiles
iii) Water storage
-Snow cover, depth and water content
-Soil moisture
iv) Surface hydrological parameters
-Precipitation and evaporation
-Water run-off
6. Ice
-Area distribution of various types (including sea-ice)
-Surface characteristics (albedo, roughness, thickness, etc.)
-Melting rates
-Dynamics

The other fact that stands out from Table 1 is the need to monitor trace gases and other chemical species. Acceptance of this requirement is a relatively recent development, but one that is assuming increasing importance.

Ocean and Climate - The ocean transports about 30% of the total heat energy of the Earth's system between the equator and the tropics. The heat storage of the first five metres of the oceans is approximately equal to that of the atmosphere. The oceans therefore play a crucial role in our planet's climate, but unfortunately the dynamics of the ocean and the heat-exchange processes with the atmosphere are nonlinear. They show variabilities on time scales extending from days to decades to centuries and beyond.

The fact that some climate anomalies (viz the El Nino and the Southern Oscillation (ENSO) can already be attributed to the variability of the ocean has led the World Climate Research Programme to set up two large scale experiments: TOGA (Tropical Ocean and Global Atmosphere) for monitoring and even predicting ENSO-type events and related climate anomalies, and WOCE (World Ocean Circulation Experiment) for estimating and modelling the ocean's global heat and water transport to the precision necessary for evaluating its climatic impact. Estimating salt transport by the ocean is also a very sensitive indication of the water cycle, which is an essential component of climate. A second component of the WOCE experiment recognises the need to address two specific questions:

i) What is the natural variability of the ocean heat and water transport, and what are the climatic consequences?

ii) What will be the response of the oceans to anthropogenic perturbations of the climate?

Both are closely linked to changes in the atmospheric component of the climate machine.

Ice and Climate - Although permanent ice sheets cover about 10% of the Earth's land surface, they are still the least-studied and least-understood major component of man's environment.

Little has been done to determine their exact dimensions, or to record variations in the Arctic and Antarctic ice.

Ice sheets exist as a consequence of climate, yet over large areas of our planet's surface they also control the climate. The high albedos of ice and snow interact with other factors to produce feedbacks that influence the overall sensitivity of the climate system. Ice sheets radiate heat to space, and their effectiveness in doing this varies with their areal extent and surface elevation. The biggest ice sheet - that of Antarctica (14,000,000 square km) - is intimately linked to the circulation of the ocean and atmosphere and even the depth of the World's seas.

Major changes in the volumes of the polar ice sheets affect both sea level and climate. Increased melting from the surface of the ice sheets and from more numerous icebergs in Antarctic waters would alter the ocean's density structure. This melting could have a strong impact on the circulation of deep ocean waters and on heat exchange between ocean and atmosphere. The atmosphere would also be affected by any decrease in ice albedo associated with enhanced surface melting.

Perhaps the strongest link between climate and the polar regions lies in the potential amplification at high latitudes of future climatic warming due to increased concentration of "greenhouse" gases in the atmosphere. It is essential to assess the present mass balance of the Arctic and Antarctic ice sheets in order to predict probable ice-sheet responses to the large temperature increases predicted for polar regions. In addition, systematic monitoring of ice characteristics could provide the first detection of such a change. Early responses are likely in sea-ice extent, ice-surface temperatures, and the extent of summer melt zones on the ice sheets.

Land Surface and Climate - The characteristics of the land surface are closely linked to climate as the balance of thermal energy at the surface exerts a major influence on atmospheric circulation and the distribution of surface energy. This balance is principally influenced by the input of surface radiation, the upward transport of heat into the atmosphere (by turbulent convection and net infrared radiation) and the heat required to evaporate water from vegetation. Heat conduction into the soil and local orographic effects can also be important.

Another factor that is now recognised as being of great importance is the nature of the vegetational cover. This determines evapotranspiration, surface albedo and surface roughness - all factors that can markedly affect the transfer of energy at the surface, and hence climate. Atmospheric climate modelling shows that the precipitation over continental areas and the temperature contrast between continents and oceans, together with associated monsoon circulations, are sensitive to the availability of moisture at the land surface. This in turn is very dependent on the nature of the vegetation cover.

Modelling of the impact of vegetation on climate requires detailed knowledge of the characteristics of the vegetation and the physical-biological processes that can occur. The requisite knowledge is not available at present. Recognising this and other problems, the International Satellite Land Surface Climatology Project (ISLSCP) was launched to exploit the capability of remote sensing to observe vegetation cover and other significant land-surface properties on a wide scale.

Another problem attracting increasing attention is that of scaling, as even if full knowledge is available of an individual site it is not clear how to scale this over larger areas for use in climate models.

3.3 Environmental problems - pollution

The increasing concern about our environment is reflected in the need to monitor not only longer-term changes, which fall within the auspices of the World Climate Programme as mentioned above but also shorter-term variations. Here the aim is to exploit the ability of satellite-borne instruments to provide information globally.

Atmosphere - Reference has already been made to the "ozone hole" and the need to monitor the levels of ozone and other trace gases in the stratosphere has been stressed. Many chemical species as well as water and aerosol content need monitoring, not to mention the intrusion of volcanic dust. The need is for comprehensive data sets partly to monitor the "health" of the stratosphere, but also to improve levels of understanding of the various processes that occur. Without the latter it will not be possible to appreciate the significance of specific observations. This requirement extends to the usual meteorological variables (temperature, wind, humidity and pressure) as these define ambient conditions.

Moving lower, into the troposphere, there is again a need to advance beyond current levels of information based on vertical profiles of meteorological information and visibleinfra-red images. Only in exceptional instances can they be used to monitor incidents such as the spread of a pollutant. There is a need to extend our capabililties firstly so that more information is provided on the chemical species present, and secondly to enhance the indirect detection of events/perturbations, such as the presence of sulphur dioxide. Progress depends principally on the levels of aerosol that can be detected.

Ocean and Seas - Recent concern over levels of pollution in the North Sea and the Mediterranean have served to highlight the importance of monitoring the oceans and seas closely. The accuracy ofsuch observations is very dependent on making accurate atmospheric corrections, including allowance for the presence of aerosol.

Essentially the requirement is to monitor the spread of pollutants, the presence of algae and plankton, sea-surface temperatures, salinities and surface wind speeds. Given this information it would be possible not only to monitor incidents such as oil spills but also to detect changes in properties that might affect fisheries or atmospheric circulation for example. Sea ice also needs to be monitored in this context.

Surface - Continuous observations of the land-ice surface are essential to increase our understanding of the various processes occurring and their variation with time. This data has to be provided both globally and regionally.

Areas of particular importance as far as environmental monitoring and impact are concerned include desertification, land degradation and land transformation (whether natural or man-made). Another area of importance, but one which poses great challenges, is the assessment of vegetation stress-damage and the monitoring of changes in these parameters.

It will also be necessary to monitor areas damaged or transformed by erosion, pollution and salination, to carry out disaster assessments (flood, fire, earthquake etc), and to identify sites for waste disposal, dam construction, etc.

The meeting of these differing requirements will not only aid planning, but will also facilitate response to catastrophies of one form or another.

3.4 Resource management and monitoring

Unless the monitoring of resources is addressed by Earth observation, it will be very difficult to make optimum use of the Earth's renewable and non-renewable resources, which could have severe economic implications.

Agriculture and renewable resources - Some progress has already been made in the use of existing satellites to monitor agriculture, forestry, vegetation and hydrology, but major problems remain, including:

-determination of the quantitative relationship between satellite vegetation indices and vegetation

- prediction of crop yields from satellite estimates of precipitation, temperature, and insolation

- assessment and prediction of changes in the amount and quality of soil and water resources.

To solve these and other challenges, optimal sampling strategies need to be devised and all-weather crop-monitoring systems developed.

Overall measurement objectives in this domain include the monitoring and assessment (on global, regional and local scales) of crops, vegetation, forests and other renewable resources, to which must be added the measurement of precipitation, temperature, and insolation for crop-yield models.

Geology and non-renewable resources - The geological history of the Earth is largely recorded by the characteristics, geometry, and age distribution of the rocks making up the continental crust. Consequently, its mapping holds the key to a better understanding of our planet's geological past. As most of the Earth's nonrenewable resources occur within this continental crust, such investigations are also the key to advancing our knowledge about their genesis and occurrence and to improving our ability to discover new mineral and hydrocarbon deposits.

Key questions to be addressed with remotely sensed satellite data include :

- What geological characteristics are generally associated with the presence of mineral and hydrocarbon resources ?
- How are soil formation and degradation affected by climate, topography, vegetation, and geologic substrata?
- What relationships exist between the characteristics of vegetative cover and geological conditions for different climatic regions of the Earth ?

The appropriate measurement objectives include:

- mapping of the distribution, geometry, and dominant lithologies of continental rocks
- identification of constituent mineralogy of soils and rock units
- mapping of past and present drainage patterns
- detection and mapping of faults and other fractures in the Earth's surface
- measurement and mapping of the topography of the Earth's surface

- location and measurement of thermal anomalies on the Earth's surface

Many of these are also "solid Earth"-related goals.

3.5 Operational meteorology

The role of operational meteorology is to provide information on the state of the atmosphere to a wide variety of users, ranging from the general public to commercial customers. This information consists essentially of weather forecasts tailored to the needs of a given user, which places stringent operational constraints on the forecasting system used in terms of quality, timeliness and reliability. The value of a forecast is crucially dependent on its quality and accuracy. Timeliness is equally crucial, since a forecast is worthless if it arrives too late to be acted upon. Finally, a forecasting service must be reliable, day in and day out, with no interruptions of service.

Any forecasting system has two key constituents : observation, which provides knowledge of the initial state, and the forecasting model which predicts the future state of the atmosphere.

The observational element encompasses such basic meteorological elements as surface pressure, wind, temperature and humidity as well as precipitation, cloud, radiation and surface state (sea state, sea-surface temperature and wind, snow-ice cover, etc).

Atmospheric data are required from the surface boundary layer to the upper levels of the stratosphere.

Satellite observations are crucial for global weather prediction due to the almost continuous coverage they afford in space and time.

Three types of forecasts can be distinguished:

Nowcasting or very short-range forecasts - These cover predictions up to about 12 hours ahead and their primary purpose is safety, both for property and for human life. Satellite imaging must therefore be available in near real time with high reliability. At latitudes of less than 50 degrees, these data requirements are ideally met by geostationary satellites. Polar-orbiting systems offer valuable complementary information for higher latitudes.

Short-range forecasts (12-72 hours ahead) - Here the primary purpose is again safety, but economic considerations assume increasing importance. These forecasts are provided more and more by numerical models covering limited hemispheric and global areas. Horizontal resolutions of the order of 100 km (for limited areas down to 20 - 30 km) are already quite common. These types of forecast models require accurate quantitative observations of the basic meteorological parameters with particular emphasis on wind observations, and a high level of timeliness and reliability. Satellite observations and available in-situ observations need to be integrated into the model by means of four-dimensional data-assimilation procedures.

The rapid developments in computing are making numerical modelling and data-assimilation ever more accurate.

Medium-range forecasts (3-15 days ahead) - The primary purpose is economic in that these forecasts are used mainly for planning activities. They are provided by advanced global models with high horizontal and vertical resolution (present horizontal resolutions are around 100 km). The models have many similarities to those for short-range prediction, but imply more advanced methods for describing physical processes such as the exchanges between the Earth's atmosphere and surface. This type of forecast requires accurate quantitative observations of the basic meteorological parameters including observations from the surface of the Earth. Satellite data are again crucial in view of the global requirements. Resolution will be improved further to some 50 km by 1995.

Thus, in summary, except for the provision of nowcasting information including weather alerts, today's operational forecast systems are using advanced numerical models. These models will gradually evolve with available computing power, which is expected to increase by an order of magnitude every six years or so over the next decades. The rapid developments in numerical modelling and data-assimilation systems over the last decade have made it possible to extend medium-range prediction skills to seven days and to provide accurate prediction of intense cyclone development up to five days ahead.

Over the next ten years, however, we will approach a situation in which further improvements will require significant improvements in the observational database. The fundamental objective of a space observing programme, therefore, must be to address the problem of increased accuracy in the three-dimensional determination of wind, temperature and moisture in the free atmosphere, with the determination of the wind field the major priority.

3.6 Solid Earth

With the ability of modern satellite-based microwave and laser ranging systems to measure the magnitude and rate of small surface displacements with centimetre accuracy and with the advent of new spaceborne sensors to measure the geopotential directly, the solid-Earth community expects to make a substantial contribution to our understanding of the structure and dynamics of the Earth's crust and interior.

Geokinematics - The major research objective for the next decade is a better understanding of the forces driving the continental motion and plate deformation, in association with the study of seismology, with special emphasis on transitional, active areas of continental collision. This requires the monitoring of plate motion and accurate measurements of spatial and temporal displacements in seismic areas, with centimetre accuracy and with a temporal resolution of a few days.

A second objective is to investigate the exchange of energy between the rotation of the Earth and atmospheric motion, and the effect of mass displacements inside the Earth and at its surface on our planet's rotation. This requires measurement of the short-term variations in the Earth's rotational parameters with milliarcsecond accuracy and a time resolution of a few hours to a few days.

For both objectives, the essential operational requirement is to establish a reference grid on the Earth's surface against which motions can be observed over distances from a few kilometres up to continental scales. The only means of meeting this requirement is a space mission providing precision positioning.

Improved positioning will also be of direct use in applications such as civil engineering for large-scale constructions, for establishing or improving geodetic networks, for photogrammetric control for aerial and space imagery, for geological investigations of neotectonic patterns, and for the navigation of ships, aircraft and land vehicles.

Geophysics - Substantial benefit has already been gained here from gravity information over the oceans derived indirectly from satellite altimetry. The short wavelength gravity field structure over the oceans reflects such structural irregularities of the ocean lithosphere as elastic deflections caused by the loading of volcanic formations. It also reveals the geometry of numerous hot spot tracks, of waveform faults or unknown seamounts.

There is a clear trend in solid-Earth research towards study of the continental lithosphere, which is much less well understood than the oceanic lithosphere. A good knowledge of gravity-field variations will contribute greatly to a better understanding of the continents. Data of sufficient quality is currently available only for a small portion of the continents, and not at all in polar regions.

The long-wavelength geoid is well determined over both oceans and continents. Recent attempts to correlate it with the internal density structure of the Earth's mantle, as given by seismic tomography, have shown the need to use dynamic Earth models, i.e. to include the effect of the internal loading on the configuration of interfaces like the core-mantle boundary and the Earth's outer surface. We thus have a first picture of the configuration of mantle convection. On the other hand, small scale convection just below the oceanic lithosphere has also been postulated from the analysis of the altimetry geoid.

Climatology and Sea-Level Rise - Global climatic changes as a result of human activities can have far-reaching consequences. Sea-level rises due to the melting of polar ice, believed to be a consequence of the man-induced greenhouse effect, will create problems on a worldwide scale. Estimated rises vary from 50 cm to 2 m over the next century. Hence large areas of the globe, and in Europe in particular, are vulnerable to this process, with extremely serious consequences in terms of flood control, surface- and groundwater level management and ecology.

Only by establishing a global monitoring network can a better understanding be achieved of how the additional water masses may enter and spread within the global ocean circulation pattern. A network of primary tide gauges, VLBI-stations, a very accurate geoid model and continuous altimetry measurements are the fundamental ingredients of such a system.

Dynamic Oceanography - Our current model of the geoid (i.e. the theoretical global undisturbed ocean surface) is derived from global gravity field information. In combination with past and future satellite altimetry data, it will be possible for the first time to display actual global ocean circulation features. This will open up a new era in dynamic oceanography with wide-ranging applications in research and applications fields.

Gravity and Magnetic Fields - Clearly, precise knowledge of the Earth's gravitational field, globally and homogeneously, is a key factor in the fulfilment of most of the solid-Earth research and applications objectives. It is also the mandatory first step towards its scientific use in theoretical physics where, in the long run, one will be able to address such fundamental questions as the existence of a fifth force or the space-time structure of the gravitational field.

Apart from the rapidly time-varying component of ionospheric origin, the Earth's magnetic field is mainly created by a dynamo process within the external liquid part of the core, and by the crustal field arising from the magnetisation of rocks. The first component dominates at large wavelengths, and its long-term variations provide physical constraints for the study of the geodynamo problem. This would in turn provide some insight into the physical mechanisms responsible for the medium and long-term variations in the Earth's rotation.

The crustal anomalies that dominate at short wavelengths are linked with the crust's thermal structure via the Curie critical temperature. They have also proved useful in identifying active and fossil collision zones and in understanding the associated mechanism of crustal doubling.

Many of the observational techniques needed for solid-Earth investigations are almost directly applicable to lunar and planetary exploration, particularly those for magnetic and gravitationalfield determination. The successes achieved in analysing mass distribution features on the Moon and Mars from a first determination of their rough gravity field structures demonstrate that advanced field mapping techniques have exciting applications beyond the boundaries of our planet.

4. EVOLUTION FROM EXPERIMENTAL TO OPERATIONAL PHASE

4.1 Introduction

The previous sections have attempted to provide a picture of the present status of remote-sensing, in the context of the main branches of the Earth sciences to which it can contribute, and of the efforts needed to ensure effective use of the technology in support of human society. Bearing in mind the recommendations of the Ministerial Conference in November 1987, the objectives for an ESA Remote-Sensing Programme spanning the next 15 years can be summarised as follows:

- ESA should continue to support the main Earth-science disciplines through a series of remote-sensing missions, either ad-hoc, or multidisciplinary.

- ESA should promote the use of remote-sensing data in application domains, to demonstrate their operational utilisation, and when possible their commercial value.

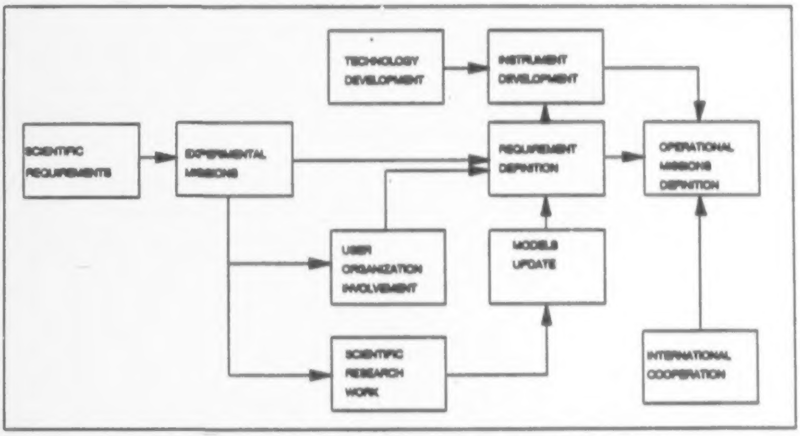
- The achievement of operational status for remotesensing is a major objective. It is believed that truly commercial undertakings will follow, if successful operational applications can justify continuity of remote-sensing measurements over long periods and on global scales.

- Similarly, related scientific research should continue to be funded to improve our knowledge of the phenomena under study, our understanding of the measurements performed by spaceborne instruments, and to establish the necessary mixture of ground- and space-based measurements, to sustain a given application. The above implies that the scientific research in remote-sensing areas should be subject to the same priorities as the applications fields.

- The operational domains to be addressed by the ESA Earth-Observation Programme, in terms of both scientific research and applications demonstration, are:

- meteorology
- climatology
- environment monitoring - global, regional and local
- vegetation monitoring, to support agricultural crop monitoring, yield forecasting, and forest extent and status monitoring
- hydrology
- land-transformation processes
- ocean and ice monitoring, in support of ocean applications, and shipping in ice-covered or in ice-infested waters.

Achievement of the above long-term objectives forms the major rationale and strategy of ESA's Earth-Observation Programme. Transformation from the experimental phase to a fully operational enterprise, a step inherent in the objectives defined, will be a complex and gradual process as illustrated in figure 1.


TECHNOLOGY DEVELOPMENT
INSTRUMENT DEVELOPMENT
SCIENTIFIC REQUIREMENTS
EXPERIMENTAL MISSIONS
REQUIREMENT DEFINITION
OPERATIONAL MISSIONS DEFINITION
USER ORGANIZATION INVOLVEMENT
MODELS UPDATE
SCIENTIFIC RESEARCH WORK
INTERNATIONAL COOPERATION

THE PROCESS TOWARDS OPERATIONAL REMOTE SENSING

Figure 1

The example of the Meteosat Programme being developed by EUMETSAT into a fully operational enterprise is misleading in that the use of satellite techniques for operational meteorology was a natural extension of an established requirement by a well-organised internationally coordinated community (WMO) which had previously been totally dependent for its global observations on a combination of weather observing stations, weather ships, balloons and aircraft.

Most of the other themes - environment, land management, and solid Earth - which have been shown here to require major space-based programmes, are not supported by such well-established and organised communities as in the meteorological sphere.

4.2 Pre-requisites for operational remote-sensing

By considering the various fields of application addressed as objectives, we can arrive at a set of conditions that have to be satisfied for remote-sensing to make an operational contribution:

i) Continuity of the data, and therefore of the space systems and associated ground facilities, over long periods (e.g. decades). This is strictly related to the nature of the phenomena being studied, with time constants varying from a few hours to several years, the latter being predominant in such areas as climatology and environment, which might well be the critical domains in future years.

Past experience shows quite clearly that it takes a minimum of ten years from the moment when data is first provided to a community to the point where user communities become firmly established and the first operational applications emerge. During this period the community has to be nurtured and encouraged to exploit the data. The need for continuity and ready availability of data is axiomatic, the experience with the meteorological community being very representative in this case.

ii) Adequacy of the space data for these operational activities, e.g. problems of cloud cover, space-time sampling, measurement accuracy, etc.

iii) Timely delivery of data to operational user-entities; for example in a matter of hours for the monitoring of dynamic phenomena.

iv) Strong coordination with the relevant user communities, which need appropriate tools to handle and interpret properly the data provided (e.g. meteorological community with numerical forecasting models) in an operational environment.

The importance of continuity of the space segment cannot be stressed too strongly. Without it, operational-commercial user communities will not develop, as there will be little incentive for long-term investment in the necessary ground resources. This also applies to many of the research communities, which require long runs of data to achieve their objectives, a point well illustrated by the needs of climatologists, since climatic changes cannot be detected over periods of weeks or months. In this case data spanning years or even decades are required. This illustrates the limited usefulness, in an overall perspective, of limited-duration, isolated, technology-oriented, ad-hoc missions.

Using ERS-1 as a starting point, the following section outlines the elements that should constitute ESA's Remote-Sensing Programme for the nineties and beyond.

4.3 Elements for an evolutionary remote-sensing Programme

4.3.1 ERS-1 and follow-on

Introduction

The already approved ERS-1 Programme must provide a platform for scientific and application demonstration activities dedicated primarily to the areas of oceanography, ice monitoring, vegetation monitoring, environment and pollution monitoring. These activities must involve the operational entities in the relevant domains, irrespective of whether or not they presently use remote-sensing products. A promotion programme based on the ERS-1 instruments and data sets must be undertaken. The goal is to implement an ERS-type operational service supporting meteorology, oceanographic applications and ice monitoring and contributing to resource management over land surfaces, in the second half of the decade.

Continuity with the ERS-1 payload, with the adequate upgradings, must be ensured to encourage the investment required for the development of operational applications and to allow continuation of scientific work in support of such applications.

The ERS-1 mission is currently presented as an experimental pre-operational system with a wide spectrum of objectives in the fields of meteorology, oceanography, glaciology, climatology and monitoring of land processes through the utilisation of a combination of, primarily, all-weather microwave sensors (radars). This payload represents a considerable step in the direction of global environmental monitoring.

Actions required

The implementation of a fully operational ERS-type service, i.e. a global service with the low-bit-rate sensors over the oceans, and a regional service with the Synthetic Aperture Radar over land, ice and coastal zones, would call for:

(i) A complete scientific understanding of the measurements performed by the various sensors and their validation (e.g. wind-wave fields, land-ice-ocean imaging with the SAR, etc.). This work would be aimed particularly at improving the models used for the geophysical interpretation of the remote-sensing data.

This effort is assumed to take place in the ERS-1 and ERS-2 time-frame, and success depends upon the support of the worldwide scientific community.

(ii) The implementation of application experiments to demonstrate the potential of ERS-type data for operational and commercial applications. Appropriate pilot projects and demonstration experiments would be defined by the Agency in close collaboration with user entities. To be fully effective such activities need to cover a time span greater than the lifetime of a single satellite; hence the role of ERS-2 in the ESA programme.

(iii) The setting of a major Promotion Programme, which, in addition to activities of the type described under (ii), would include training, education, contact with other data-reception stations, identification of potential user entities, etc. The primary goal of these promotional activities would be to stimulate interest and involve such bodies as:

EEC : for agriculture, forestry, land use, environment monitoring, marine resources , etc. in both developed (EEC Member States) and developing countries (through the Commission's Directorate General VIII - Development Aid).

United Nations entities such as UNEP, FAO and major international programmes for developing countries (desertification, locust plagues, fisheries).

World Bank, Asian Development Bank, African Development Bank and similar entities for the implementation of pilot projects around the World.

Governmental entities in Member States with local-regional-national responsibilities in various areas of land and ocean resources, as well as environment monitoring. There is an enormous increase in public concern (and consequently in that of governments) about environment monitoring and large amounts of funding are now being allocated to this domain. Clearly, remote-sensing from space is going to play a major role in monitoring of climate change, ozones, deforestation, desertification, oceanic pollution, etc.

Meteorological offices which are already extremely interested in low-bit-rate data (wind, wave, sea-surface-temperature) for operational numerical forecasting models.

Ice-forecasting centres (Canada, Scandinavia) are also very keen on receiving SAR data over ice for their operational activities in ice-infested zones.

(iv) Implementation of an operational remote-sensing scenario, derived from the ERS system, probably as part of the Polar-Platform, will probably require further modification of the instruments in the light of the pre-operational experience. For instance, there are already indications based on the experience already gained in planning detailed user scenarios of the need for modifications to match the user requirements better in terms of space-time sampling, of sensor measurement specifications, of operating modes, of data delivery to users, of improvements to processing algorithms and to operational models adopted by user entities, etc.

(v) The financial and legal arrangements, whereby the cost of an operational ERS-type system whould in principle be shared between ESA and the user entities, need further clarification.

By proceeding in the above way, the initial experimental programme, with a large scientific component, can develop gradually into a fully operational set-up, with a number of well identified large customers, whilst still maintaining the possibility of serving the research community, and eventual small users.

4.3.2 Associated elements

ESA recognises the importance of scientific and application-oriented research in improving confidence in remotesensing's in contributions to our knowledge of the Earth's phenomena. The scientific community must be guaranteed access to long series of historical data sets, including data from spaceborne, airborne and ground-based instruments, duly calibrated and correlated. Therefore, in addition to supporting the work of scientists and the application-demonstration programmes, ESA must, in cooperation with the appropriate national and international institutions, contribute to the creation in Europe of adequate databases with European and possibly worldwide coverage, containing reliable historical data sets, comfortably accessible to European scientists (but not exclusively). These databases should have enough growth potential to be able to accept data from future remote-sensing missions, as well as from ground and airborne campaigns yet to take place, as soon as they become eligible for historical archive.

The importance of coherent and reliable data sets underlines once more, the crucial role of calibration and validation activities, which need to form an integral part of every mission. Future missions therefore need to be prepared by adequate ground work, supported by airborne campaigns, aimed at tuning the characteristics of the spaceborne instruments, demonstrating their potential, and giving the user entities confidence in the quality of the data, by performing the necessary engineering calibration of the sensors, and the geophysical validation of their data. Availability of the necessary facilities for these activities (aircraft, airborne sensors, teams for ground work, etc.) must be ensured by the appropriate national or international bodies, in cooperation with ESA.

4.3.3 Future instruments and platforms

To encourage the development of operational applications in particular in the domains of environmental monitoring and resource management, and to support them once established, ESA will undertake the study and development of a coherent, multidisciplinary set of sensors. The scale of the objectives demands that, whenever possible, contributions be sought through international cooperation, or national contributions by Member States. ESA must also ensure that these instruments are deployed in space on a series of platforms, according to a well-defined plan, coherent with the various objectives.

Recognising the global nature of most of the applications addressed and the commercial potential of many non-European regions (South America, Canada, Africa, India, China, South-East Asia, Australia, all oceans), ESA will ensure global coverage (with its own sensors or others providing compatible data sets) with the frequency required by the applications addressed, via international cooperation whenever possible.

ESA will endeavour, within the limits of its mandate and its resources, to guarantee that Europe has available the means to play a leading role in the critical areas of Earth environmental monitoring and Earth-resources management, on a global scale.

The necessary infrastructure, consisting mainly of in-space communications and a ground segment equal to the task in hand, including ground stations, processing facilities, archives and catalogues, data distribution facilities, user support centres, payload operation planning facilities, will be set-up by ESA, in cooperation with national centers, along the same lines as the ERS-1 ground segment.

The development of meteorological geostationary satellites will continue to be supported in cooperation with EUMETSAT.

4.3.4 Non-ESA missions

ESA will be the means whereby data from missions from non Member States will be made available to European users. This element refers in particular, and in the short time frame, to Landsat-6, J-ERS, Radarsat, etc.

It is highly desirable for ESA to enter into negotiation with the Member States that have remote-sensing missions (France), or are developing remote-sensing instruments as part of national programmes (Italy, Federal Republic of Germany), in order to harmonise the various programmes and arrive by the turn of the century at a unified European Programme incorporating, on a set of compatible platforms, instruments aimed at commercial exploitation, operational packages for some established applications, and payloads dedicated to scientific objectives.

5. LONG -TERM STRATEGY

5.1 Introduction

The European Long-Term Strategy for Earth observation should be centred around the following major themes:

- Monitoring of the Earth's environment on various scales, from local or regional to global.
- Management and monitoring of the Earth's resources, both renewable and non-renewable.
- Continuation and improvement of the service provided to the worldwide operational meteorological community.
- Contribution to the understanding of the structure and dynamics of the Earth's crust and interior.

These issues which are of concern to all of the World's nations, call for well-coordinated international cooperation. No one nation can afford to develop and operate the complex space system and the ground infrastructure necessary to handle the resulting data.

Europe, and ESA in particular, has made considerable progress during the last twenty years in establishing its own advanced space technology and therefore has all the resources, both technological and intellectual, needed to make a major contribution to a global Earth-observing system.

5.2 Proposed strategy

The proposed strategy consists of establishing and implementing a comprehensive and coherent set of space missions in geostationary, low-inclination and polar orbits which would :

- satisfy the specific investigative objectives described in Section 3 (data requirements summarised in Table 1);

- provide continuous data over periods of more than a decade to both scientific and operational users;

- satisfy the space-time sampling and orbit requirements of the various users;

- capitalise on the European launcher and platform capabilities that will be available in the 1990s;

- further develop operational and commercial utilisation of remote-sensing data to encourage user entities to participate in the funding process in the medium term;

- pursue international cooperation to support joint scientific and application programmes ranging from access to and exchange of data with other international partners, to the deployment of spaceborne systems realised via a coordinated contribution of instrument packages.

Four major space-programme elements have been identified for implementing this strategy and achieving the European goals:

1. **An Environment-Monitoring Programme**

2. **An Earth-Resources Management Programme**

3. **An Operational Meteorology Programme**

4. **A Solid-Earth Programme.**

This integrated set of programme elements is interrelated and interdependent. Each element requires data from a number of different spaceborne systems, deployed in a coordinated fashion. Conversely, each spaceborne system contributes essential data for achieving the objectives of more than one (in some cases all) of these four programme elements. This is illustrated in table 2.

SPACE PROJECTS / PROGRAMME ELEMENTS	ERS-1 ERS-2	ARISTOTELES	EPOP A SERIES	EPOP B SERIES	METEOSAT 1ST GEN. (+ LASSO)	METEOSAT 2ND GEN.
ENVIRONMENTAL MONITORING	✳	✳	✳	✳	✳	✳
EARTH RESOURCES MANAGEMENT	◇	◇	◇	✳	◇	◇
OPERATIONAL METEOROLOGY	✳		✳	◇	✳	✳
SOLID EARTH	◇	✳	◇	◇	◇	

✳ - MAJOR CONTRIBUTION

◇ - USEFUL CONTRIBUTION

TABLE 2: CONTRIBUTION OF SPACE PROJECTS TO PROGRAMME OBJECTIVES

5.2.1 Environment monitoring programme

The proposed ESA strategy is to meet those objectives described in Section 3 for the monitoring of the environment, in terms of :

- radiation and clouds
- atmospheric physical and chemical variables
- precipitation
- ocean-surface variables
- land-surface variables
- ice parameters.

Ultimate success will be very dependent on the provision of appropriate instrumentation packages to be embarked on a combination of polar and geostationary platforms developed both by Europe and by other space nations. Important European contributions will be provided by ERS-1/2 and the Meteosat series of satellites especially if the ERS-1 mission can indeed be extended with an ERS-2. Generic instrument packages to be deployed on these various space platforms include :

- Instruments derived/upgraded from those developed for ERS-1/2 and Meteosat (and therefore providing continuity of data) such as :

Wind Scatterometer
Radar Altimeter
Synthetic-Aperture Radar, and a
Visible-Infrared Imaging Radiometer.

- New instruments such as:

Medium Resolution Visible-Infrared Imaging Radiometers and Spectrometers
Passive Microwave Imaging Radiometer
Backscatter LIDAR
Doppler Wind LIDAR
Limb Sounder, and an
Earth Radiation Budget Instrument,

plus other instruments that may emerge from the various Announcement-of-Opportunity processes.

5.2.2 Earth-Resources monitoring and management programme

A similar approach is also necessary here to provide data for the management and monitoring of Earth resources, in such areas as:

- land surface properties
- surface hydrological parameters
- snow and ice distribution
- vegetation cover
- geological features.

Achievement of these goals will also depend on the provision of appropriate instrumentation packages, to be embarked primarily on polar platforms developed through international cooperation.

ERS-1/2 and the Meteosat series of satellites will contribute by monitoring soil moisture, vegetation cover, crop/ forest distribution, snow and ice cover, and geological features.

Generic instrument packages needed will include :

Medium-Resolution Visible-Infrared Imaging Radiometer
High-Resolution Visible-Infrared Imaging Radiometer and Spectrometer
Synthetic Aperture Radar
Passive Microwave Imaging Radiometer
Altimeter,

again plus other instruments that may emerge from the various Announcement-of-Opportunity processes.

5.2.3 Operational meteorology programe

The driving force here is the need to meet the ever-increasing demand from meteorological offices, in particular European, for global measurements of such atmospheric parameters as :

- surface pressure
- wind field
- temperature
- humidity
- precipitation
- clouds and radiation
- surface parameters (over sea and land).

To meet these objectives, appropriate instrumentation packages need to be embarked on a combination of both polar and geostationary platforms developed by Europe and other space nations.

Europe is already making a major contribution to the international global meteorological satellite observing system by providing one of the five participating geostationary meteorological satellites, namely, Meteosat, as well as some of the instrument packages on the operational US NOAA-TIROS polar-orbiting satellite series. In the near future, ERS-1/2 will provide additional useful data, such as ocean surface wind and wave information.

Generic instrument packages to be deployed on the various future space platforms to meet the operational meteorological needs include:

- Improved versions of current instruments, such as

Visible-Infrared Imagers
Microwave Sounders
Infrared Sounders
Wind Scatterometers

as well as still to be developed instruments such as

Doppler Wind LIDAR
Surface Pressure Sounder
Backscatter LIDAR
Earth Radiation Budget Instruments,

plus other instruments that may emerge from the various Announcement-of-Opportunity processes, initially for experimental purposes but, in the longer term, becoming operational.

5.2.4 Solid-Earth programme

As noted in Section 3.5, the first "cornerstone" is a dedicated mission to map the gravity field of the Earth (and possibly also its magnetic field) globally and with sufficient accuracy to meet the research requirements not only of Earth scientists, but also those imposed by the needs of advanced space-based observation techniques.

Improved knowledge of the gravity field, so derived, will finally overcome the error penalty imposed by present gravity-field information on orbit determination, and hence on range measurements. The need for specially designed, dedicated and expensive spacecraft for solid-Earth missions will then largely disappear. Future missions can then be performed from multipurpose Earth-observation platforms and will serve to tie together many of the interdisciplinary observations made from the same platform.

Strategic planning for the future will therefore focus on the development of new technologies for microwave and optical space-based tracking systems, and on the use of flight opportunities on the forthcoming Polar-Platform elements of European and international space programmes.

The strategy foresees the continued use of these platforms as a prime means of establishing consistent data sets for the monitoring of vital environmental parameters and, ultimately, for predicting climatic changes and earthquakes. The replies to the Announcements of Opportunity for the first European Polar Platform reflect this trend.

5.3 Implementation

Realisation of the strategy outlined involves the development, launch and exploitation of a combination of space missions in geostationary, polar and specific-to-mission orbits, as illustrated in fig.2.

5.3.1 Geostationary-orbit mission: Second-Generation Meteosat

Second-Generation Meteosat (MSG) would provide data of improved quality, and possibly also new data products, such as profiles of temperature and water vapour, which would improve weather forecasting in the short, medium and longterm and on the associated local, regional and global spatial scales. MSG would also make a major contribution to environmental studies.

Based on a policy of systematic involvement of the operational and scientific meteorological communities through EUMETSAT, the baseline definition of the MSG includes the following possibilities:

- a much improved imager to fulfil the needs of an increasing number of meteorological applications such as short-period weather forecasting;

- a new mission to provide the atmospheric temperature and water-vapour profiles content needed to strengthen numerical weather-forecasting models;

- a small package of instruments to enhance the scientific return of the new programme;

- a much improved data-circulation mission to disseminate more data more quickly and in a much more flexible manner.

Many of these improvements will require the application of advanced technologies, a responsibility of the Agency. It is foreseen that the financing of this programme would be shared with the European meteorological community through EUMETSAT.

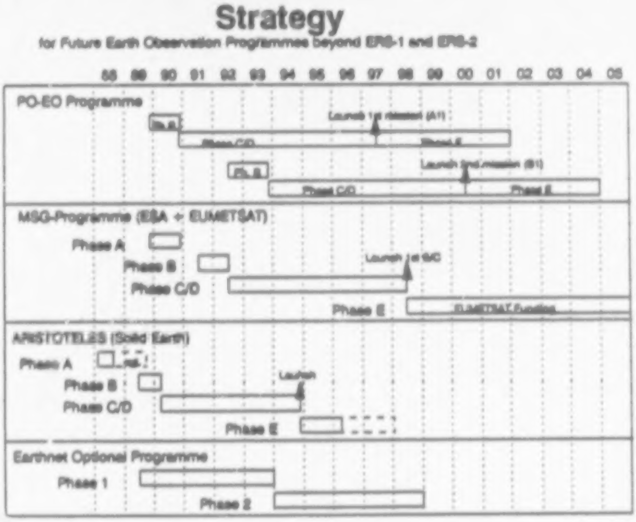


Figure 2

The first launch in the MSG programme is planned for the second half of the nineties, to ensure continuity with the present Meteosat Operational Programme.

5.3.2 Polar-orbiting mission : Polar-Platforms system

Taking into account:

- the overall requirements in terms of instrumentation to be flown on the Polar Platforms;
- the operational maturity of some of the payloads;
- the European launcher capabilities available in the 1990s;
- the need to have a cost-effective, minimum-risk and maximum-reliability system to operate successfully in orbit over long periods;
- the need to satisfy the very diverse space-time sampling requirements of the different user communities,

it is concluded that, even taking into account that the European platform will be complemented by the Polar Platforms of other Space-Station partners (e.g. NASA and, possibly, Japan), two series of European Polar Platforms deployed in a phased and coherent manner ("PARALLEL" scenario in Figure 3) provide the optimum means of meeting all requirements.

In fact, having only one series of platforms would present major difficulties for a number of reasons. This would lead to platforms of very considerable size, having to accommodate a large collection of instruments, with subsequent problems of accommodation (e.g. in terms of field of view, electromagnetic cleanliness, interference, etc.), and in operations (conflict in utilisation of platform resources such as power, difficulty of simultaneous operation of sensors, etc.). The increased risk of failure at launch or in an early phase of the mission would not be acceptable. Furthermore, orbit requirements vary considerably in terms of altitude, repeat-cycle and local time at equator crossing. Some users such as the operational meteorologists are insisting on a fast repeat cycle with an early morning and early afternoon local time, while others such as the land applications community need longer repeat-cycles, with a local time around 10.00 hrs. etc. The main advantage of a single large platform is that it would reduce the launch and some operational costs. However, it would be at the expense of payload flexibility, as indicated above. Clearly, there is an optimally-sized platform to meet the overall European Earth Observation strategy; it is within the range currently being studied.

Generally, it is assumed that the payloads on both series A and B European Polar Platforms will include :

- Operational instruments with additional research capabilities, developed and funded by the appropriate operational agencies.
- Core-facility instruments developed and funded by ESA and the other Space-Station partners.

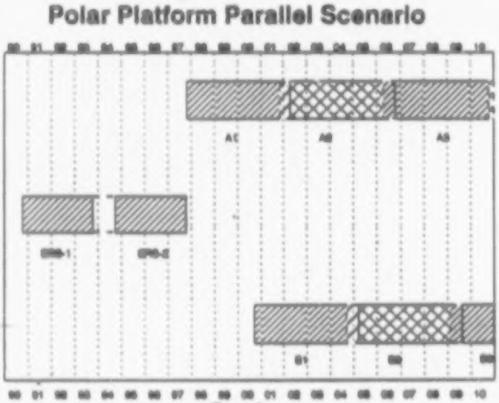
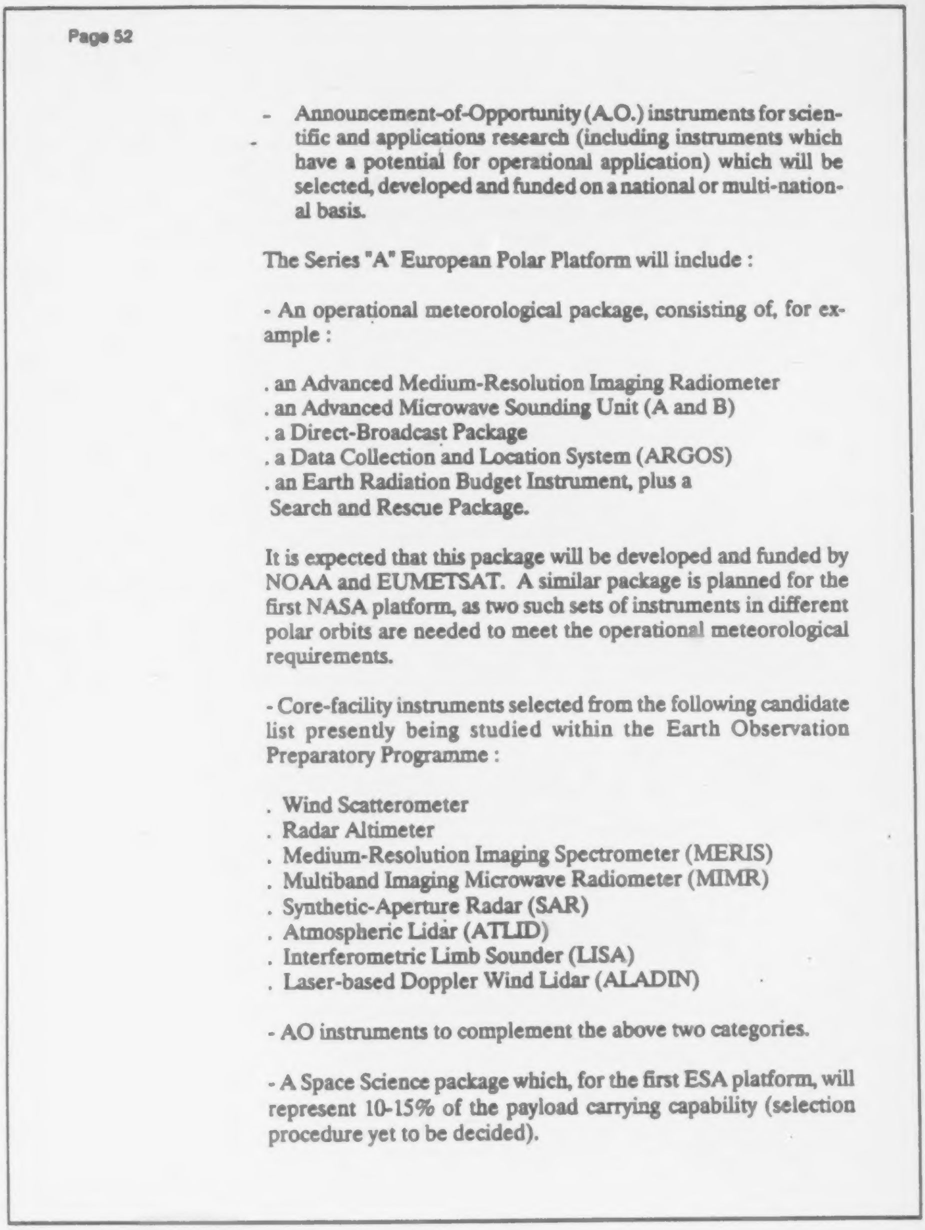

Polar Platform Parallel Scenario

Figure 3



- Announcement-of-Opportunity (A.O.) instruments for scientific and applications research (including instruments which have a potential for operational application) which will be selected, developed and funded on a national or multi-national basis.

The Series "A" European Polar Platform will include :

- An operational meteorological package, consisting of, for example :

. an Advanced Medium-Resolution Imaging Radiometer
. an Advanced Microwave Sounding Unit (A and B)
. a Direct-Broadcast Package
. a Data Collection and Location System (ARGOS)
. an Earth Radiation Budget Instrument, plus a
Search and Rescue Package.

It is expected that this package will be developed and funded by NOAA and EUMETSAT. A similar package is planned for the first NASA platform, as two such sets of instruments in different polar orbits are needed to meet the operational meteorological requirements.

- Core-facility instruments selected from the following candidate list presently being studied within the Earth Observation Preparatory Programme :

. Wind Scatterometer
. Radar Altimeter
. Medium-Resolution Imaging Spectrometer (MERIS)
. Multiband Imaging Microwave Radiometer (MIMR)
. Synthetic-Aperture Radar (SAR)
. Atmospheric Lidar (ATLID)
. Interferometric Limb Sounder (LISA)
. Laser-based Doppler Wind Lidar (ALADIN)

- AO instruments to complement the above two categories.

- A Space Science package which, for the first ESA platform, will represent 10-15% of the payload carrying capability (selection procedure yet to be decided).

The Series-"B" European Polar Platform will include instruments selected from the candidate list presently being studied within the Earth Observation Preparatory Programme :

. High-Resolution Imaging Spectrometer (HRIS)
. Very-High-Resolution Optical Imager (VHROI)
. High-Resolution Thermal Infra-red Radiometer (HRTIR)
. Medium-Resolution Imaging Spectrometer (MERIS)
. Synthetic-Aperture Radar (SAR)
. Interferometric Limb Sounder (LISA)
. Altimeter

plus AO instruments, as appropriate.

It is very important to note that the final payload composition will depend on such factors as the choice of the platform, its payload capabilities, and the priorities of the user communities. Consequently, a revision of these lists of instruments will take place for ALL categories (operational, core facility, science package and AO instruments) given such clarification. Furthermore, it is envisaged that some instruments developed by ESA may be embarked on the NASA platform(s) if appropriate (e.g. MERIS, LISA, ALADIN).

5.3.3 Specific-to-mission orbit: ARISTOTELES

The concept for a first solid-Earth mission which resulted from various studies conducted by ESA defines a single spacecraft named ARISTOTELES (Applications and Research Involving Space Techniques Observing The Earth fields from Low Earth orbit Spacecraft) which is planned to be launched, together with another polar orbiting satellite, in the mid-1990s by an Ariane vehicle.

ARISTOTELES will orbit the Earth at an altitude of about 200 km for a period of 6 months to perform its primary gravity-field mapping mission. Thereafter, the spacecraft will be raised to an altitude of around 700 km, where it will remain for another 3 years to be used as a geodetic satellite for precise positioning.

The ARISTOTELES spacecraft's gravity gradiometer consists of a two-dimensional arrangement of four accelerometers which measure the motions of freely electrostatically suspended proof masses. Simulations have demonstrated that this arrangement will permit the measurement of gravity gradients with a resolution of 0.01 Eotvos units, i.e. 1 nanogal-m and the recovery of mean 1 degree x 1 degree surface gravity anomalies to better than 5 mgal.

In order to address its other mission objectives, namely magnetic-field determination and precise point positioning, ARISTOTELES would have to be equipped with a boom-mounted scalar magnetometer and precise microwave tracking systems. Candidates for the latter payload element are the PRARE (Precise Range and Range-Rate Equipment) already under development for ESA's remote- sensing missions, and a GPS (Global Positioning System) receiver.

5.3.4 Ground Infrastructure : Earthnet Programme

In the framework of the Agency's Long-Term Space Plan, Earthnet is charged with the payload data-handling functions of the Earth-Observation ground segment. Therefore, it defines, implements and operates the ground data system for payload data acquisition, archiving, cataloguing, preprocessing and dissemination for experimental, pre-operational and selected commercial remote-sensing missions developed and operated by the Agency or by otherspace organisations.

Following the decisions of the Ministerial conference at The Hague, the Earthnet programme will comprise two parts :

-a mandatory portion covering basic activities and financed within the General Budget;

-an optional portion covering data promotion and exploitation activities to be financed within the envelope of the Earth Observation Programme.

The basic activities will continue to cover the tasks associated with handling of data from on-going or historical remote sensing missions such as ERS, Landsats 1 to 5, TIROS, MOS, Nimbus-7, Seasat, etc. and will ensure the associated user services aspects.

The optional programme will complement the tasks listed above by fulfilling several objectives; it will

- promote the use of the remote-sensing data and, in particular, of ERS data utilisation with the aim of ensuring worldwide awareness of its potential for the various fields of application and maximising return on investments;
- provide the European remote sensing user community with data from various third party missions including data from the International Polar Platforms, thereby ensuring data continuity to users for a wide range of sensors with time and space sampling suitable to satisfy their research, application and operational objectives;
- prepare the nucleus of the ground segment that could be reused for the exploitation of data from the EarthObservation payload of the European Polar Platform;
- increase the presence of participating States' industry in the market for ground stations, processing chains systems, added value services.

All the above have the long-term goal of transferring the derived commercial/operational activities to existing or yet to be created exploitation organisations.

CONCLUDING REMARKS

It is now universally recognised that mankind faces a number of major problems of an environmental nature that require global, as well as regional and local perspectives for their solution. This realisation gives added impetus to the Earth-observation programmes of all the space agencies. In particular it focuses attention on the need for ESA to have a firm agreed strategy for Earth observation that takes into account the central role of observations from space in striving towards a better understanding of and the ultimate solution of these problems.

In this report the major requirements for observations from space have been categorised into :

-Environment (climate change and pollution aspects)

-The management of both renewable and non-renewable resources

-Operational meteorology

-Solid Earth.

Building on this recognition of the major problem areas to be addressed, the potential contributions of the traditional scientific and associated user disciplines of atmosphere, ocean, ice, land and solid Earth have been briefly surveyed and the basis for the overall Earth observation strategy thereby derived.

The programmes that need to be adopted to fulfil the aims of this strategy have then been derived, leading in turn to the proposal of a number of interlinked satellite systems that together constitute the practical means for implementing the programmes, namely:

1. A successor to ERS-1 (in the medium term)

2. Second-generation Meteosat

3. A dedicated Solid Earth mission - ARISTOTELES

4. The Polar Platform missions (in the longer term).

Also, the need to build up the ground segment in parallel with the space segment leads to the recognition of the central role of Earthnet in the long-term strategy, especially for those aspects concerned with the development of fuller operational and commercial systems.

A fundamental aspect is that observations primarily directed towards one problem area usually impact significantly on others. For example, the improved definition of the geoid provided by the Solid-Earth Programme, when taken in conjunction with radar altimeter measurements from other satellites, would make a significant contribution towards a fuller description of the synergism between the general global sea level rise and oceanic circulation needed for the Climate Change Programme. Similarly, the requirements of operational meteorology will also make vital inputs to the Climate Change and Land Management Programmes. The proposals that constitute the strategy for Earth observation contained in this report are mutually interdependent, and should be considered and hopefully adopted in their entirety.

A major part of the strategy is to encourage the development of operational and commercial user communities in the expectation that in the long term these communities will shoulder an increasingly larger proportion of the financial burden. In this respect it is recognised that governmental and inter-governmental organisations will be major customers. One of the roles of Earthnet will be to spearhead the promotion of Earth-observation products for these users.

A basic strategy driver is the need for continuity: firstly to meet the scientific, application and operational needs, and secondly to give potential commercial/operational users the confidence to invest in the development of the necessary ground processing and infrastructure in the expectation of long-term growth.

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The proposed strategy for the Agency's Earth-Observation Programme for the coming decades would not only allow Europe to contribute substantially to the solution of problems relevant to the future habitability of the Earth, but would also be seen as a dramatic indication of ITS political will to play its PART in the enterprise.

ANNEX I

CONTACT WITH USER COMMUNITIES

1. Solid Earth Mission/ARISTOTELES

- SONG (Elmau, 1978)
- SESAME (Ising, 1986)
- MATERA (1987)
- Interim working group on Satellite Geodesy and Navigation (1976/77)
- Panel on Earth Sciences of the Solar System Working Group (1978)
- Earth-oriented Research Working Group (1980-86)
- Solid Earth Working Group (1982-86)
- Gradiometry working Group (1988-)

2. Second Generation Meteosat

- The Avignon Workshop (June 1984) and specific follow-on workshops at Hohenschwangau (March 1986), Ravenna (November 1986) and Santiago (May 1987) as well as the pre-phase A concluding workshop in Bath (May 1988)
- The setting up of five consultant/expert groups to provide the Executive with a definition of the instruments constituting the satellite payload
- The regular consultation with the Meteorological Advisory Committee (METAC)

3. Polar Platform

- POPE Working Group on Earth Observation requirements for Polar Platforms (May 1986)
- ESPOIR Workshop in Avignon (June 1986)
- Setting up of a number of ad-hoc Expert Groups to assist the Executive in the definition of instruments, systems and campaigns (ten groups are currently in place)

- Symposia/Workshops on specific Earth Observation topics, e.g. Ocean Colour Worshop in Villefranche-sur-Mer (November 1986), Imaging Spectrometer Workshop in Frascati (April 1988), Workshop on Commercial Opportunities for Remote Sensing with Polar Platforms in Frascati (September 1987)
- Regular consultations with the Earth Observation Advisory Committee (EOAC) and specialised working groups (Land Working Group, Ocean Colour Working Group ...)
- Issue of a call for Earth Observation Instrumentation for the first ESA polar platform (January 1988)
- Systematic presentations on the Polar Platform activities at international forums for remote sensing, colloquia, conferences, symposia etc (eg IGARSS, ERIM, IAF, EARSeL ...)
- Close involvement with major scientific initiatives in Earth Observation such as WOCE, TOGA, GEWEX, IGBP .....

ANNEX II - List of Acronyms

ALADIN	Atmosphere LAser Doppler INnstrument
ALT	(radar) ALTtimeter
AMRIR	Advanced Medium Resolution Imaging Radiometer
AMSU	Advanced Microwave Sounding Unit
AO	Announcement of Opportunity
ARGOS	French satellite-borne data relay and platform-location system
ARISTOTELES	Applications and Research Involving Space Techniques for the Observation of The Earth's fields from Low-Earth-orbit Spacecraft
ATLID	ATmospheric (Backscatter) LIDar
CNES	the French national space centre (Centre National d'Etudes Spatiales)
DB	Direct Broadcast
EARSeL	European Association of Remote-Sensing Laboratories
EEC	European Economic Community
ENSO	El Nino/Southern Oscillation
EO	Earth Observation
EOAC	Earth Observation Advisory Committee (ESA)
EOPP	Earth Observation Preparatory Programme (ESA)
EOSAT	The EOSAT Company (USA)
ERBI	Earth Radiation Budget Instrument
ERIM	Environmental Research Institute of Michigan
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ESPOIR	European Symposium on Polar platform Opportunities and Instrumentation for Remote sensing
FAO	Food and Agriculture Organisation

GEWEX	Global Energy and Water cycle EXperiment
GPS	Global Positioning System (USA)
HRIS	High Resolution Imaging Spectrometer
HRTIR	High Resolution Thermal Infrared Radiometer
IAF	International Astronautical Federation
IGARSS	International Geoscience And Remote Sensing Symposium
IGBP	International Geosphere-Biosphere Programme
IOI	In-Orbit Infrastructure
ISLSCP	International Satellite Land Surface Climatology Project
ISRO	Indian Space Research Organisation
J-ERS	Japanese Earth Remote sensing Satellite
LANDSAT	LAND remote-sensing SATellite
LASSO	LAser Synchronisation from Stationary Orbit
LIDAR	LIght Detection And Ranging instrument
LISA	(Interferometric) LImb Sounder
MERIS	MEdium Resolution Imaging Spectrometer
METAC	METeorological Advisory Committee
MIMR	Multiband Imaging Microwave Radiometer
MOP	Meteosat Operational Programme
MSG	Meteosat Second Generation
NASA	National Aeronautics and Space Administration (USA)
NASDA	NAtional Space Development Agency (Japan)
NOAA	National Oceanic and Atmospheric Administration (USA)

POEOP	Polar Orbit Earth Observation Programme
POPE	Polar Orbiting Platform Elements (ESA Working Group)
PPF	Polar PlatForm
PRARE	Precise RAnge and Rate Equipment
RADARSAT	RADAR SATellite (Canada)
SAR	Synthetic Aperture Radar
SESAME	Solid Earth Science and Application Missions for Europe (ESA Workshop 1986)
SONG	Space Oceanography, Navigation and Geodynamics (ESA Workshop 1978)
SPOT	Systeme Probatoire d'Observation de la Terre
S & R	Search and Rescue
TIROS	Television Infrared Operational Satellite
TOGA	Tropical Oceans and Global Atmosphere
TOPEX-POSEIDON	Ocean TOPography EXPeriment
UNEP	United Nations Environment Programme
VHROI	Very High Resolution Optical Imager
WCP	World Climate Programme
WMO	World Meteorological Organisation
WOCE	World Ocean Circulation Experiment

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE
ASSISTANT DIRECTOR
FOR GEOSCIENCES

September 24, 1990

Honorable Ralph M. Hall
Chairman, Subcommittee on International
  Scientific Cooperation
U.S. House of Representatives
Washington, D.C. 20515

Honorable Bill Nelson
Subcommittee on Space Science
  and Applications
U.S. House of Representatives
Washington, D.C. 20515

Dear Congressmen Hall and Nelson:

It was a pleasure to be able to assist the Subcommittees on International Scientific Cooperation and on Space Science and Applications during the hearings on July 24. Enclosed are responses to the additional questions posed in your letter of September 6.

Sincerely,

Robert W. Corell
Assistant Director

Enclosure

Followup Questions for Dr. Corell
from July 24 Testimony

QUESTION 1: In your testimony on July 24, you made reference to the International Group of Funding Agencies for Global Change Research, which met in Bonn this summer. This group is scheduled to hold its first combined meeting in January of 1991 to consider a broad range of resource issues related to international global change research.

A. Who from the United States will participate in this meeting?

B. What authority will U.S. representatives bring to any discussion of "resource issues?" Which U.S. agency representative(s) will be responsible for pressing limits or matching requirements to the amounts of resources allocated?

C. Are there plans to consult with Congress prior to the meeting or prior to formal decision making on the subject of international resource issues?

D. Will the group attempt to clarify what is "equitable sharing" of funds for climate change research?

E. Will this group focus on ways to contain or reduce the total cost of international global change research?

RESPONSE: The International Group of Funding Agencies for Global Change Research (IGFA) met in January and July of this year and is scheduled to meet next on 4-6 February 1991 to consider a broad range of resource issues related to international global change research. It is expected that three representatives of the Committee on Earth and Environmental Sciences' (CEES) Working Group on Global Change will participate in this meeting: I as Chairman of the Working Group; Dr. J. Michael Hall of NOAA as Vice-Chairman; and Dr. Roberta B. Miller of NSF as Chairman of the Working Group's Task Group on Human Interactions.

The Group's discussions of resource issues focus on the review and exchange of information on national research programs. These discussions are intended to identify gaps and/or overlaps in funding of international global change research which can then be addressed through the national funding mechanisms within each country. IGFA neither commits resources nor makes decisions with respect to international resource issues.

If the Group's discussions identify resource allocation issues of critical importance to the U.S. Global Change Research Program, these issues will be addressed by the CEES and its member agencies in their regular review of the U.S. Program and will, if necessary, be reflected in revisions to the plan for the U.S. Global Change

Research Program and in concomitant agency submissions to the Congress for support of this Program. Funding agencies in other countries will similarly address issues of importance to them through their national funding processes.

QUESTION 2: You have indicated that ICSU's Advisory Committee on the Environment will sponsor an international forum every two years to promote interaction among the scientific, business, and governmental organizations. Will the interests of business and industry be represented in the planning process through any means other than these infrequent forums?

RESPONSE: ICSU's newly established Advisory Committee on the Environment (ACE) will develop and maintain an interface with partners in private business and industry. A senior science officer has been hired to staff the ACE. This officer's responsibilities will include promoting and improving cooperation and information exchange with private business and industry on a day-to-day basis. This regular interaction between ICSU and private business and industry will complement the biannual Forum, which will bring together all sectors active in global change research - the scientific community, intergovernmental organizations, national funding agencies, and private business and industry.

III. INTERNATIONAL DEVELOPMENT PROGRAMS FOR COMMERCIAL EARTH OBSERVATIONS

An Analysis

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BASIS FOR ANALYSIS

- National programs studied vary considerably in degree of sophistication, research to operational development, and commerciality.

- Programs are arbitrarily compared and ranked internationally for potential commerciality as to seven factors:

    Commitment of Government Funding
    Commitment of Private Sector Investment
    Joint Government-Industry Policy Mechanisms
    Vertical Integration of Space Data to User
    Links between Basic Science, Applied Science, and Commercial Development
    Usefulness of Sensor Data
    Commitment to Program Continuity

- Programs are analyzed by country as space segment, ground segment, and information systems programs.

- Programs are classified as:

    National Research and Commercial Development Programs
    International Consortia
    National Education and Training Programs

- Programs are analyzed with respect to the transition from R&D to stand alone commerciality.

BASIS FOR ANALYSIS

Earth observation programs in countries included in this study vary from those currently in the government funded study stage for development during the period 1990-2000 to the presently sophisticated and quasi-commercial programs such as in France or in the United States. These programs also vary from research and experimental to potentially fully commercial (space plus ground segment) during this period. Thus, the commerciality of these programs vary from being in the initial planning stages to early implementation currently requiring continued market development and investment to reach stand alone commercialism by the year 2000.

These national programs are summarized and compared on page --an arbitrary basis as to their relative potential commerciality at present and for the period 1990-2000. Seven factors affecting commercial potentiality are ranked on an arbitrary scale of 0-10 (10=highest commercial potential). These factors are: Commitment of Government Funding; Commitment of Private Sector Investment; Government-Private Sector Mechanisms for Joint Program Policy Development and Implementation; Vertical and Horizontal Program Integration (space segment to information for user); Mechanisms to Link Basic Earth Observation Science Programs with those for Applied Research and Commercial Development; Usefulness of Planned Satellite Sensor Data; and National Commitment to Continuity for the Earth Observation Systems. Based on these arbitrary evaluations, the non-U.S. satellite producing countries are ranked in their order of decreasing commercial potential for earth observations for the period of 1990-2000 as France, Japan, Canada, ESA, Brazil-PRC, India, FRG, and the USSR.

The commercially ranked programs are then analyzed in detail on a country by country basis. In each national program, organizations currently developing remote sensing in the space segment, the ground segment, or as information systems are examined as well as their interlinkages where appropriate. Programs and projects of these organizations are presented as national research and commercial development programs, international consortia, and national education and training programs. Each national program is analyzed for its current status and projected status through the year 2000 in the development cycle from research and development to commercial self-sufficiency. The viability of each country's commercialization efforts for earth observations are further analyzed in the following section on the analysis of commercial applications opportunities for 1990 through 2000.

COMPARISON OF NATIONAL PROGRAMS FOR COMMERCIAL EARTH OBSERVATIONS

COUNTRY	70 MAX	GOV'T FUNDING	PRIVATE SECTOR(PS) FUNDING	GOV'T-PS POLICY LINKS	SPACE TO USER LINKS	BASIC APPLIED SCIENCE COMM'L LINKS	UTILITY OF DATA	CONTINUITY
FRENCH SPOT	65	10	8	10	9	9	9	10
JAPAN JERS	60	10	7	10	7	10	9	7
CANADA RADARSAT	54	10	5	10	8	8	8	5
ESA ERS	48	8	5	7	5	8	8	7
BRAZIL- PRC CBRS	47	8	3	9	7	8	7	5
INDIA IRS	46	10	2	7	6	7	7	7
FRG MOMS	43	8	5	10	5	7	5	3
SOYUZKARTA GLAVKOSMOS	41	10	2	5	5	7	6	6

FRANCE

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

The French national earth observation program is a well-integrated system from the space segment through the ground data management systems to the information systems, including the value-added and other user communities. The primary parent organization is the national space agency, Centre National d'Etudes Spatiales (CNES). CNES owns the French earth observation satellite, SPOT, and the ground station and pre-processing data facilities.

The SPOT Program is operated by the Spot Image Corporation which is a mixed private sector company (Society Anomonie) whose shareholders consist of CNES (35%), three French user agencies, IGN (Institute Geographique National, 11%), IFP (Institute Francais Petrole, 4%), BRGM (Bureau de Recherches Geologiques et Minieres, 1%), private industry including aerospace manufacturers SEP (11.5%) and MATRA (23.5%), and French Banks (4%), as well as international partners SATIMAGE (Sweden, 6%) and the Belgian Government (4%). Spot Image is thus presently 61%-39% government-private sector owned. Spot Image operates the SPOT satellite, the ground processing facilities, the archiving and the marketing and development of SPOT data. Spot Image owns the satellite data markets through a network and of international ground stations and its own subsidiaries, SI Corp in the U.S. and Spot Image Services in Australia. Spot Image conducts applications, demonstrations, and pilot programs through its Technical Marketing and Development Department in conjunction with CNES and SCOT (see below) with numerous user agencies and private sector users internationally. Data processing and algorithm development are conducted with SCOT and shareholders SEP and MATRA through their software-hardware joint venture MS21. Education and training is conducted in conjunction with GDTA (see below).

SCOT CONSEIL is a private sector company 100% owned by CNES, a government organization. SCOT's primary role is to develop customer ground receiving stations, in-house image processing systems, GIS systems, and other user earth observation capabilities to further develop the user market for SPOT data. SCOT provides worldwide consultancy including turnkey capabilities and economic studies. SCOT works as a link between potential users for image processing, Spot Image for data, GDTA for education and training, and MATRA and SEP for image processing, and the value-added companies (see Appendix A).

GDTA (Groupment pour le Development de la Teledetection) is a G.I.E. (Groupment d'Interest Economique - group of companies interested in joint economic enterprises) organization whose members include mainly government or mixed government-private sector user agencies. These members include BRGM, CNEMAGREFF (Forestry Agency), CNES, ENGREEF (Ministry of Agriculture), FAO (Ministry of Foreign Affairs), IFP, and IGN (See Chart F-1). GDTA conducts cooperative research and applications development for the user members. It conducts a series of education and training programs for national and international users of SPOT data.

PROSPACE is a "trade association" of CNES and 55 French companies and organizations associated for the promotion of the activities, products, and means of the French space industries including earth observations.

ANALYSIS

It is important to recognize that all of the above organizations are inter-linked both vertically and horizontally to further the development and ultimate commercialization of the French SPOT program. For example, recent efforts by Spot Image to develop the market for SPOT data in Mexico were enhanced by linkages to the other organizations. Spot Image was assisted by the French Embassy, the French Science Mission, SCOT, and CNES. Potential customers were lead directly to French companies producing hardware, software, and value-added services. Education and training courses were offered through GDTA. Such cooperative linkages work in all directions between the various organizations and are a hallmark of the integrated French earth observations program.

PROGRAMS AND PROJECTS

Throughout the activities of the organizations above, many individual programs and projects are conducted on behalf of the development of the French national earth observation program. Principal programs and some project examples follow.

National Research and Commercial Development Programs

Basic earth observation research is conducted through CNES and CNRS (Centre National de la Recherche Scientific) with various user agencies and national and university laboratories such as LERTS, Laboritoire for Research in Space Remote Sensing. Applied research is conducted through CNES, Spot Image, and SCOT with GDTA and the various user agencies and the value-added and information companies.

Commercial development programs are conducted jointly and singularly by CNES, Spot Image, and SCOT. They consist of Pilot Projects, Demonstration Projects, and Technical Marketing and Development programs and projects.

AVAL Program. This major program consists of pilot projects conducted and funded jointly by CNES and Spot Image (50%) and proposing industry/customers (50%). The purpose of the AVAL Program is to speed up the commercial and operational utilization of SPOT data and develop operationally useful SPOT products, equipment, and services. The AVAL projects are proposed by industrial users with assistance from CNES-Spot Image. Once accepted, they are jointly funded to develop a new use or application of earth observation data with the results to be exploited by the user partner for commercial purposes.

Demonstration Projects. These projects are run primarily by SPOT Image to identify potential customers and provide demonstration examples as start-up. They provide flexible spin-off demonstrations to service companies, sub-contractors,and users.

Technical Marketing and Development. These projects are conducted by Spot Image, sometimes with SCOT, for customer development at cost plus overhead. They include project management during pilot and demonstration projects, and post pilot/demonstration project operational advice and consultancy.

International Cooperation and Consortia

The French earth observation program and its organizations are involved in a number of international consortia or cooperative programs. The SPOT Program is itself an international consortia between CNES, the Swedish Space Agency (6% ownership), and the Belgian Government (4% ownership), which is reflected in their respective shares of the Spot Image Corporation. The Swedish participation through the Satimage Corporation provides the northern ground station at Kiruna, Sweden, which provides ground receiving capability for the receipt of taped data from most orbital paths for global coverage for the SPOT program. This coverage supplements that from other international ground receiving stations worldwide. CNES is a participating partner in the earth observation programs of ESA, the European Space Agency. This partnership includes participation in the non-commercial Meteosat meteorological satellite program and the development of the ERS-1 earth resources satellite to be launched in 1990. CNES is a joint partner with NOAA in the U.S./French Topex/Poseidon oceanographic research satellite to be launched in 1990.

The Spot Image Corporation and SCOT conduct a number of cooperative pilot and demonstration projects with various international agencies and value-added companies worldwide. The purpose of such programs is to expand the global user community for SPOT data. International participants include the World Bank, the European Economic Council (EEC), and the Swedish Space Corporation among others. A large number of projects are conducted through the French Foreign Affairs Office with foreign government agencies in developing countries. These include geological, agricultural, timber, and land use mapping in Algeria, Botswana, Brazil, Morocco, New Caledonia, Nigeria, Philippines, Saudi Arabia, Tunisia, Zimbabwe, and other developing countries. SCOT is conducting a major international agricultural statistics and vegetation/water resource inventory with ISPRA.

National Education and Training Programs

Education and training (E&T) programs are conducted throughout the French earth observations development programs at CNES, Spot Image, SCOT, and many government user agencies. However, GDTA has the primary role for education and training devoted to expanding the user market in France and abroad. Students are provided to GDTA through CNES, Spot Image, and SCOT as well as GDTA's parent user agencies BRGM (mining), CNEMAGREEF (forestry), ENGREEF (agriculture), FAO (foreign affairs), IFP (petroleum), and

IGN (mapping). E&T programs are designed for both entry level and experienced earth observation users. Experienced users focus on use of SPOT data, products with "hands-on" SPOT data sets and re-education of users for stereo photo-interpretation. Current programs involve 100-150 trainees per year, of which 20-25 pursue 9 month courses (CETEL)and the rest take 1-8 week courses (CETIT, R.S.C., SITEL, SPOT, SIG, SITAU). GDTA is currently expanding its education and training programs by offering courses in Asia, Africa, and other countries expressing interest.

Additional education and training courses are conducted within user agencies and companies with assistance from Spot Image and SCOT. Courses are offered in many universities with primary academic centers for remote sensing at the Universities of Paris, Strasbourg, and Toulouse.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The French SPOT Program has passed through the research and development phase, the testing and verification phase, and is presently passing from the applications and demonstrations phase of development into the commercial products and services phase of the normal commercial development cycle. At present, SPOT data sales cover about 50% of the cost of the ground segment of the system. This includes royalty payments to CNES for data supplied from the SPOT satellites. Sales are expected to cover all of the ground segment costs by 1995 and 50-80% of the space segment costs by the year 2000, bringing the SPOT program 85-90% full commerciality.

Research and Development

During the late 1970's, the French national space agency CNES decided to develop its own French earth observation satellite, SPOT. CNES was joined in designing the SPOT satellite by several user agencies, notably BRGM, IFP, and IGN. SPOT's design took advantage of basic R&D and experience drawn from the Landsat Program and was designed to provide high spatial resolution (10 and 20 meters IFOV) VNIR (visible and near infrared) spectral data with cross-track stereo, thus supplementing the Landsat data. SPOT was designed to focus on serving the agricultural, timber, land use, and cartographic industries. It was originally anticipated that the SPOT program could be run on a commercial basis after the government subsidized the SPOT-1 R&D and that data from SPOT 1 would pay for the building of SPOT-2. This has been revised so that CNES will continue to subsidize the satellite segment through Spot 4 (1999). CNES is studying a radar earth resources satellite with X-band SAR to compliment the SPOT program in 2000-2001. Research is being conducted by CNES with Acatel and Electronique Serge Dassult.

Testing and Verification

In the early 1980's, CNES, along with GDTA, conducted the SPOT Data Simulation Study (1980-1984). This verification program involved some 150 potential users of SPOT data world-wide which served to develop an experienced user base. By 1984, CNES, with its user agencies along with some aerospace participation and in partnership with the Swedish and Belgian space agencies created the Spot Image Corporation to operate the SPOT Program and commercialize the ground segment. CNES will conduct validation tests of the proposed radar satellite at the Toulouse Space Center in 1992.

Applications Demonstrations and Demonstration Projects

From 1984-1986, Spot Image and CNES conducted the SPOT Early Assessment Program (PEPS) which provided almost 200 researchers with new SPOT satellite data for research and applications evaluation and demonstration. This program directly established an important international user base for SPOT data. Applications, pilot, and demonstration projects as well as education and training programs were expanded after 1986 by CNES, Spot Image, and GDTA and subsequently by SCOT after its formation in 1987. These programs and projects have been directed at technical and market development and have been augmented by the growth of a supporting value-added and information services industry (See Appendix A).

Commercial Products and Services

The development of commercial products and services commenced with the launch of SPOT 1 in 1986 through Spot Image Corporation and its subsidiaries, SI Corp., USA, and Spot Image Services, Australia. Products and services have expanded through a growing network of international ground stations and value-added and information service companies worldwide. Current revenues presently pay about 50% of all ground segment costs, including data royalties to CNES. Spot Image 1989 revenues were 130 MFF ($20.8 million)

Current revenue growth projections indicate the ground segment will be fully commercial by 1995 and the total SPOT space and ground segment will be about 90% commercial by the year 2000. Private sector investment in Spot Image has grown to 39% in 1989. CNES has assured the SPOT program of continuity through 1999 by agreeing to subsidize the cost of the space segment through SPOT 4 (1995-1999).

ANALYSIS AND PROJECTION

The French national SPOT earth observation program is well on its way towards commercial maturity. Government subsidy of the satellite space segment will continue through the 1990's but should be phased out beyond 1999. SPOT commercialization is supported by the government's willingness to subsidize the satellite segment until orderly market development for the SPOT data can take place over a 10-15 year period (1986-1999). The strength of the SPOT program lies in the government's assurance of continuity of the satellite data stream. During the 1990's the SPOT program will continue to focus on developing the established land and cartographic mapping market currently dominated by the airborne photogrammetric industry.

NATIONAL EARTH OBSERVATIONS PROGRAMS

JAPAN

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

The Japanese earth observation program is truly a national program that has been targeted by the Japanese government, in consort with Japanese industry, to become a major factor in international earth observations. While the Japanese program is committed to developing state-of-the-art earth observation technology and to participating in international research and development programs such as the polar-orbiting platform programs, the Japanese program is also designed to provide Japanese government and industry with global economic resource intelligence for oil/gas, minerals, agriculture, timber, and fishing. Although Japanese earth observation data will be of high quality, the government has not yet determined whether or not to commercialize its earth observation data for global distribution. The primary organizations in Japan are the National Space Development Agency of Japan (NASDA), the Science and Technology Agency (STA), for government programs (MOS- Marine Observations Satellite), ADEOS- Advanced Earth Observations Satellite, and J-POP- Japanese Polar-Orbiting Platform and the Ministry of International Trade and Industry (MITI) for industrial programs JERS (Japanese Earth Resources Satellite). A hallmark of the Japanese programs is the extensive vertical and horizontal organization of government, academic, and industrial organizations involved in Japanese earth observation programs and their consensus committee mechanisms for decision making for setting and implementing policies for national earth observation programs.

The primary organization in Japan that sets policy and provides overall guidance for national programs is the 5-man Space Activities Commission (SAC) which reports to the Prime Minister. The primary interagency committee advising SAC and other Japanese space organizations on earth observations is the Committee for the Promotion of Remote Sensing (RSPC) which is made up of several Japanese ministries that utilize earth observation data. These include in addition to STA, NASDA, and MITI, the Japanese Ministry of Agriculture, Forestry, and Fishing (MAFF), Ministry of Education (MOE), Ministry of Post and Telecommunications (MOPT), and the Ministry of Transport (MOT).

The government earth observation programs are conducted by NASDA through its Earth Observation Satellite Office. NASDA is funded and directed by its parent agency, STA, in part through its Space Development Division (STA/SDD). STA and NASDA have developed Japan's first earth observation satellite, MOS-1 (Marine Observation Satellite) launched in 1987, which will be followed by MOS-1b in 1990. MOS carries Landsat MSS-type sensors along with a microwave sensor for ocean monitoring and fishing information. STA/NASDA are co-developing the industry oriented resource exploration JERS-1 satellite (Japanese Earth Resources Satellite) scheduled for a 1992 launch. STA/NASDA are planning to follow the JERS satellite with ADEOS (Advanced Earth Observation Satellite) to be launched in 1994. ADEOS will carry Landsat type sensors with several advanced sensors provided by other countries, such as a NASA scatterometer, N-SCATT. ADEOS will be followed by the ITIR (Imaging Thermal Infrared Radiometer) System, which is an advanced thematic mapper type sensor with a multispectral thermal IR sensor being developed in cooperation with NASA in the U.S. to be flown on NASA's N-POP-1 in 1996. STA/NASDA are also planning an earth observation polar-orbiting platform (J-POP) for a 1998 launch to be operated in co-ordination with U.S. and ESA polar-orbiting platform programs in the late 1990's. NASDA operates ground receiving stations for MOS as well as Landsat and SPOT data primarily through the Earth Observation Center (EOC), Hatoyama, Japan, where data is distributed from international ground stations in Canada, Thailand, and Europe. Earth observations data is also received through facilities at the University of Tokai where earth observation R&D is conducted in cooperation with NASDA. NASDA's development of earth observation technology is further supported by research at The Institute of Space and Science (ISAS) funded by STA.

RESTEC, the Remote Sensing Technology Center of Japan, was created by STA and NASDA with aerospace corporate members in 1975. It is funded by STA/NASDA and serves to conduct R&D, collect, archive and distribute Japanese and international earth observation data, train remote sensing specialists, and provide education and international cooperation for remote sensing. RESTEC is the data distributor for NASDA's EOC to government and academic users as well as international users, often assisted by JICA (Japan International Cooperation Agency). Japan is developing the EDRTS (Experimental Data Rely and Track Satellite) which will allow ADEOS and JERS-2 (if built) data to be acquired and transmitted to EOC like NASA's TDRSS system without numerous foreign ground stations. NASDA's satellite programs are not planned for commercial development, however, MOS, ADEOS, ITIR and some J-POP data have potential commercial value if Japan decides to develop a commercial organization for earth observation data.

In 1979-1980, in response to a broad industry-government consensus through the Keidanren, Metal Mining Agency of Japan (MMAJ), Japex (the Japanese Petroleum Exploration Company,) and others, the Ministry of International Trade and Industry (MITI) decided to develop a resource satellite to assist Japanese industry in exploration and development of needed global energy and mineral resources. MITI, through its Space Industry Division (MITI/SID), then created ERSDAC, the Earth Resources Satellite Data Analysis Center, as a mixed government funded - private sector company with industry membership to conduct the R&D for, plan the JERS satellite program and provide for its data handling and distribution ground segment. Subsequent to the development of ERSDAC in 1981, STA/NASDA and MITI agreed that the JERS satellite would be a jointly funded venture with STA/NASDA responsible for building and operating the sensors and satellite and MITI/ERSDAC for designing the satellite, conducting its mission planning for data acquisition, and managing its ground distribution for industrial use. JERS research data will be provided to Japanese government agencies as well to cooperating international space agencies such as Canada's CCRS, ESA, and NASA, through cooperative agreements under the principle of non-discriminatory access to data. Japanese industrial access to JERS data will be handled through ERSDAC. The Japanese government has yet to finalize decisions on how JERS data will be made available to the general international user community on a timely basis by commercial or other means. Industry participation in the ERSDAC program is through supporting corporate membership and through the RRSS (Technology Research Association of Resource Remote Sensing System) and subsequently JAROS (Japan Resource Observation System Organization) industry organizations established under the jurisdiction of both MITI and STA. JAROS's role is to assist MITI/ERSDAC in R&D and applications development and mission planning, and data distribution for the JERS program.

ANALYSIS

The Japanese earth observation programs are characterized by broad government-industry-academia consensus mechanisms for setting and implementing policy. As typical of Japan, decisions for national programs such as the earth observations programs take a long time to be reached, but once reached through broad consensus of all parties, these decisions are carried out. Because all elements of government, industry, and academia are involved in the consensus decisions, national programs are well organized, all parties are served, and the programs are conducted in best interests of Japan. The research and technology programs of STA/NASDA/RESTEC will provide Japan with international leadership in earth observations and, coupled with MITI/ERSDAC's JERS, will provide Japan with global economic resource and environmental earth observations data to serve its national needs. If Japan decides to commercialize JERS or other data, it can be assumed that the commercialization effort will be well organized, committed to, and probably highly successful.

PROGRAMS AND PROJECTS

The Marine Observation Satellite (MOS) program of NASDA has reached operational status with current in-flight testing and verification. The MITI/NASDA JERS program is undergoing final development and preflight testing and simulation studies. NASDA's ADEOS, ITIR and J-POP systems are in the planning stage and undergoing R&D at NASDA, ISAS, and other involved agencies.

National Research and Commercial Development Programs

Basic earth observation research is conducted primarily through STA and NASDA in concert with various government user agencies such as MITI, and the Ministries of Agriculture, Forestry, Fishing (MAFF), Education (MOE), Post and Telecommunications (MOPT), and Transport (MOT), and with the Institute for Space and Science (ISAS), and various universities including Tokyo, Chiba, and Tokai. Remote sensing research is conducted by various aerospace industry and government organizations such as MITI's Electromechanical Laboratory and the Tskuba Science Center under MITI's Agency of Industrial Science and Technology (AIST) and the Mitsubishi Research Institute (MRI) among others.

Applied research is also conducted by the organizations above aided by various user organizations. These include the RRSS and JAROS organizations described above as well as the Metal Mining Agency of Japan (MMAJ), Japex Geophysical Institute (JGI), Geological Survey of Japan (GSJ), National Research Laboratory of Meteorology, National Institute for Pollution and Resources, and others. Several applications development and verification programs have been, or are being conducted as follow.

MOS-1 Verification Program. This program has been conducted by NASDA and RESTEC and the Third Symposium on MOS-1 Verification Program was held February 27 to March 1 1989 in Tokyo. The program is similar to the French SPOT PEPS program in that MOS data was provided to a large number of Japanese and international (10 countries) investigators from government, industry and academic for technical verifications and applications development studies. The MOS-1 Verification Program provides excellent background for further applications of MOS-1b data and for later earth observation system, and it has already expanded the user base for earth observations applications. RESTRC conducted a 3 year joint research program on Remote Sensing

Technology utilizing MOS-1 data with ASEAN countries (Indonesia, Malaysia, and Thailand) in 1986-1989.

JERS Simulation Studies. Since 1978, ERSDAC, under MITI, and RESTEC, under STA/NASDA have conducted applications research using simulated JERS data. JERS-1 will carry improved electra-optical sensors similar to Landsat Thematic Mapper and SPOT capabilities with more spectral bands and a L-band radar. Electra-optical simulations studies for resource mapping have been conducted in Japan and the U.S. under ERSDAC/MITI with GSJ, JAPEX, JAROS, JGI, MMAJ, and RESTEC and other user organizations. Radar simulation studies under the direction of RESTEC with the organizations above have been conducted in Japan with the Canadian airborne radar in cooperation with the Canadian Center for Remote Sensing (CCRS), and additional radar simulation studies are being planned for 1990 using the NASA/JPL DC-8 multivariant radar. It has been proposed that the Geosat Committee participate in these studies.

An example of these simulation studies is the on-going two year JERS Simulation Study being conducted in the U.S. by ERSDAC, Japex and JGI with the Geosat Committee to simulate JERS data using state-of-the-art airborne remote sensing for geologic mapping related to hydrocarbon and mineral deposits.

Because Japan has not yet decided whether it will commercialize any of its earth observation programs, there are no formal commercial development programs as such. However, some form of commercial marketing of JERS data, probably through ERSDAC, is presently under consideration by policy committees in Japan (e.g., the Committee under Dr. Ishii, University of Tokyo). Present applications development and simulation programs such as above will help develop a commercial market for JERS data.

International Cooperation and Consortia

The Japanese earth observation programs include many research and development programs and projects which involve international cooperation. Principal among these is the MOS-1 Verification Program discussed above. Along with a large number of investigations from many Japanese user organizations, this program included international investigators from Belgium, Canada, ESA, France, India, Korea, Singapore, Sri Lanka, Thailand, and The U.S. (NASA, NOAA). The Joint Geosat/ERSDAC/Japex/JGI JERS Simulation Study, the RESTEC-CCRS and NASA JERS radar simulation studies are other examples of international cooperative studies being conducted by NASDA/RESTEC and MITI/ERSDAC.

The STA/NASDA/RESTEC development of the ADEOS satellite program is considered an international project or "non-commercial consortia". ADEOS is being developed as a free-flying satellite by STA/NASDA. It will carry Landsat type electro-optical sensors provided by NASDA and several other sensors developed by international partners including a NASA N-SCAT wind scatterometer. In addition, STA/NASDA is developing with NASA/JPL the ITIR multispectral thermal infrared and advanced thematic mapper sensor system, which will be flown on NASA's N-POP-1 polar-orbiting platform in 1997. This arrangement will provide Japan access to all the NASA EOS/N-POP data through NASA-NASDA cooperative agreements. Additional NASDA planning for the J-POP for 1998 is being conducted with NASA and ESA and other countries participating in the international polar-orbiting platform programs for the late 1990's These efforts are being coordinated through international E.O.S working groups and the Committee on Earth Observations (CEO).

National Education and Training Programs

Overall direction for national education and training for earth observations comes from STA, NASDA, MOE (Ministry of Education) and JICA, the Japan International Cooperation Agency, which conducts Japan's foreign aid programs. Many user agencies conduct remote sensing education and training programs with the assistance of NASDA, RESTEC, and ERSDAC. Major academic centers for earth observations education and training include the Universities of Tokyo and Chiba and Tokai University.

RESTEC, and to a lesser extent, ERSDAC and the Geological Survey of Japan (GSJ) conduct extensive education and training programs for international earth observation users, especially in the greater southeast Asia - Pacific areas and in other underdeveloped countries. Programs are conducted with the UN for ESCAP (UN Economic and Social Committee for Asia and Pacific) members and with ASCA (Association for Science and Cooperation in Asia). These programs are conducted in Tokyo and in some developing countries. International education and training programs are conducted through the support and offices of JICA, who is conducting follow-up surveys in developing countries to assess the affectiveness of the E/T programs. These programs support education and training programs in ground receiving and market center countries such as Thailand.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The Japanese national earth observations program has been conducted to date as experimental research and technology development. Japan has demonstrated its technical capabilities by producing the MOS-1 operational marine observation satellite with all the space segment and ground receiving capabilities necessary to produce a commercial system. The STA/NASDA ADEOS, ITIR and J-POP systems are planned as experimental research systems not for commercial development, although data from both systems will have commercial applications potential. The MITI/NASDA JERS system is different in that, while considered experimental at present, it has been designed to provide operational, utilitarian data for global resource information for Japanese government and industry. The JERS data will have high commercial potential and commercial marketing of JERS data is currently being evaluated by the Japanese government.

Research and Development

During the mid-1970's, the Japanese government led by the Space Activities Commission (SAC) decided to develop an independent earth observation satellite capability. STA/NASDA initiated plans for a marine observation satellite (MOS) to be followed by a land observation satellite (LOS). Research and development for these satellites was conducted by NASDA and STA with supporting user agencies, universities, and research organizations of aerospace companies such as Mitsubishi. MOS was designed to have Landsat multispectral capability with unique microwave sensors for ocean monitoring.

By the end of the 1970's, international interest in Landsat data for global resource exploration and development led MITI and Japan's resource industry to initiate the development of the JERS-1 earth resources satellite with basic capabilities needed for geological mapping for space. These included the 1976 Geosat recommendations to NASA for Landsat Thematic Mapper and SPOT capabilities plus radar. R&D for JERS-1 was initiated by MITI through the newly created ERSDAC in 1981 with supporting user agencies and universities. A resource industry group, the Technology Research Association of Resource Remote Sensing System (RRSS), was created to help design and develop the prototype JERS. R&D for ADEOS, ITIR and J-POP are being conducted through STA/NASDA with participation by ERSDAC, RESTEC, universities, and user agencies and industry groups.

Testing and Verification

Pre-launch and post launch testing and verification for the MOS-1 satellite was conducted through STA/NASDA/RESTEC with the same users agencies and organizations above. These efforts included the MOS-1 Verification Program described above. Pre-launch verification and testing for the JERS-1 satellite has consisted primarily of the pre-launch simulation studies conducted under MITI/ERSDAC with CCRS, Japex, JAROS, JGI, the Geosat Committee, RESTEC and others.

Applications Development and Demonstration Projects

The MOS-1 Verification Program included applications development and demonstration studies with post-launch MOS-1 data. The JERS-1 simulation studies under MITI/ERSDAC/RESTEC described above are considered applications development as well as pre-launch verification studies. In simulating the JERS data, these studies will evaluate the utility of the spectral bands for geologic mapping and develop software programs maximize their practical use. The Japanese have not yet decided to commercialize JERS data and therefore there are presently no applications development and demonstration projects designed specifically for commercial purposes. However, the JERS simulation studies will serve to stimulate a market for JERS data if a commercialization decision is made by the government.

Commercial Products and Services

With no commercial earth observations programs yet in Japan, there are no commercial products or services available at this time. MOS-1 data has generally been limited to research applications with no general public distribution.

ANALYSIS AND PROJECTION

Japan has demonstrated its capabilities to produce operational earth observation systems of potential commerciality with the development of the MOS-1 satellite and ground system. The JERS satellite is being designed for practical uses by Japanese industry and government for global resource exploration and development and will provide data of high commercial potential. NASDA has expressed (1988) the need for continued government development of Japanese earth observations satellites with no rush to commercialize because the global market is still too small for successful commercial systems. MITI's initial intent for the JERS system was to provide data to Japanese industry and government without concern for commercial or other distribution to international users in competition for global resources. This issue raised the question of international non-discriminatory access to JERS data. While NASDA has assured international governmental open skies access to JERS data for research purposes, the issue of timely international user access to JERS data for commercial purposes remains to be defined by the Japanese government. MITI/ERSDAC, with the Ishii Committee, is studying the commercial market potential for JERS data and the feasibility of developing a commercial JERS-2.

While Japanese commercialization decisions remain to be made, it is likely that some form of commercial access to JERS data will be established before the 1992 launch of JERS-1. Access would be through MITI/ERSDAC. Distribution would probably involve private sector companies such as Nissho-Iwai, who presently markets Landsat and SPOT data. Because the JERS data will be the most useful data for global energy and mineral applications from 1992-1995, a significant market demand for JERS data should emerge. One drawback to the commercialization of JERS data is the lack of a global marketing and distribution system comparable to the Spot Image and Eosat organizations. Should Japan decide to commercialize JERS 1 or 2 with a strong marketing entity, Japan could become a formidable international marketer of earth observations data in the mid- to late 1990's. Even if Japan does not commercialize the availability of JERS and ADEOS data will still impact the global earth observations markets because of the anticipated usefulness of the data for many commercial applications.

CANADA

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

The Canadian national earth observations program is focused on the development of the RADARSAT satellite system. In September 1989 the Canadian government, through the Ministry of Industry, Science, and Technology (MIST), and its provincial government partners committed to building RADARSAT for a planned 1994 launch. It will provide the Canadian government and industry with ocean, ice, and land earth observation data for national information or resource management and environmental monitoring, as well as commercial radar data for the international user community. The primary organization in charge of the RADARSAT Program is the RADARSAT Project Office of the Canadian Space Agency (CSA) under MIST.

Before its transfer to the CSA in 1989, the RADARSAT Program was directed by the Canadian Center for Remote Sensing (CCRS), a division of the Ministry for Energy, Minerals, and Resources (MEMR), who has been mainly responsible for the development of remote sensing technology in Canada and for the early development of the RADARSAT Program. The RADARSAT Program has evolved in part from Canada's participation in the Earth Resources Satellite (ERS-1) Program, a radar carrying satellite, of the European Space Agency (ESA) and from studies of the U.S. SEASAT and Shuttle Imaging Radar (SIR) programs in 1978-1984. Policy for Canada's earth observing programs comes under MIST for the Prime Minister and includes participation of the CSA and CCRS. The principal advisory body is the Canadian Advisory Council on Remote Sensing (CACRS), an industry-government body, chaired by industry. Satellite sensor and spacecraft development are under CSA/RADARSAT. Satellite operations will be by the RADARSAT Mission Control Facility (MCF), while the mission direction and data receiving, processing, archiving and distribution will come under the RADARSAT Mission Management Office (MMO). The RADARSAT launch will be provided by NASA in the U.S.

The Canadian Center for Remote Sensing (CCRS) has been responsible for early development of the Canadian programs under the Ministry for Energy, Minerals and Resources. CCRS operated the Canadian remote sensing ground receiving stations at Prince Albert, Saskatchewan, and Gatineau,Quebec, where international Landsat, SPOT, NOAA, and MOS data are received, processed, archived and distributed. These international data services will be turned over to the designated private sector remote sensing operator, Radarsat International, Inc. (RSI) in April, 1990. CCRS has been and will continue to be responsible for Federal basic and applied R&D and applications development and demonstration projects with government and industry and with the provincial remote sensing centers.

Prominent partners with Canadian government in the RADARSAT Program are nine provincial governments through their centers for remote sensing. Four of these provincial governments, British Columbia, Ontario, Quebec, and Saskatchewan, have provided capital funding for RADARSAT ($53 million Canadian of $383 million total) in exchange for data. Five other provincial governments, Alberta, Manitoba, New Brunswick, Nova Scotia, and Prince Edward Island, also serve in a partnership role and will pay back the Canadian government for data used. NASA, in the U.S., is also a major RADARSAT partner in providing the Delta II satellite launch and ground receiving facilities at Fairbanks, Alaska. In exchange for these services, NASA will receive a percentage of data which will be used for research and, in part, for distribution to U.S. users through a NOAA regulated commercial entity, in compliance with the U.S. Landsat Commercialization Act of 1984.

Radarsat International, Inc. (RSI) is a private sector company that has been designated as the commercial entity to promote international use and sales of RADARSAT data. RSI is a partnership of Intera, a leading provider of airborne radar data and services, MacDonald Dettwiler (MDA), a world leader in ground receiving stations, data processing radar construction, and SPAR a Canadian aerospace company. RADARSAT data will be divided proportionately amongst its partners, the Canadian government, the Provincial governments, and NASA, with a significant percentage available for commercial sales through RSI worldwide.

Other prominent organizations in developing earth observations programs in Canada include the Canadian Remote Sensing Society (CRSS), supported in part by CCRS (publications). Basic and applied earth observation research funding is provided to both industry and academia by both the National Sciences, Engineering Research Council (NSERC) and the International Development Research Center (IDRC).

ANALYSIS

While Canada, largely through the CCRS and some provincial centers, has been a world leader in developing the use of earth observations technology, it has only recently reached the "GO" decision to fund and develop its own earth observations satellite, RADARSAT. However, to reach this stage, long term R&D, international cooperation, and design studies and planning have been conducted since the late 1970's. Canada's RADARSAT Program is a testament to getting the agreement of all involved government agencies and industry to proceed with this national program, which will develop a new type of operational satellite system serving national needs, international agreements, and commercial users with the first Canadian earth observation satellite, which is an accomplishment in itself.

PROGRAMS AND PROJECTS

Since the early 1970's, Canadian earth observations technology development has been conducted in a series of programs and projects by Canadian Center for Remote Sensing (CCRS) in cooperation with provincial centers for remote sensing, user agencies, industry and academia. A hallmark of these programs and projects has been the close cooperation between and "joint venture" approach of government, industry and academia.

National Research and Commercial Development Programs

Basic and applied research has been and is conducted by the CCRS with the provincial centers, user agencies, industry and academia, although it is not a granting agency. This research is funded by the various ways by the entities involved in each program or project. For many of these research projects, national funding is provided, in part, by the National Science, Engineering Research Council (NSERC) and the International Development Research Center (IDRC). CCRS programs and projects with various participants come under the CCRS User Assistance and Marketing Unit and the CCRS Technology Transfer Section.

Applications Research Programs. These programs or projects are usually joint government-industry studies in agriculture, forestry, geology, oceanography, and ice applications research. Industry gets subsidized data in exchange for a full public report, but has the option to keep the results proprietary in exchange for paying for the data. These studies can be run jointly through the provincial centers for remote sensing and can involve academia.

Contract Joint Government-Industry Applications Research. CCRS, provincial centers for remote sensing, and other government user agencies contract with industry to provide applications research and development and remote sensing goods and services. All combined, these government-industry contracts run $45-50 million (Canadian) annually and have served as a form of subsidy to speed the development of a viable earth observation value-added and services industry to ultimately support Canadian satellite programs.

Demonstration Projects and Pilot Studies. These projects are carried out through CCRS, provincial centers for remote sensing, and user agencies with other agencies and industry for specific applications. Funding may be from the NSERC, or IDRC, with the government-industry mix of funding a function of the degree of risk and of project goals.

Commercial Market Development. Commercial market development is now the responsibility of Radarsat International, Inc. (RSI). RSI receives the full cooperation of CCRS, the provincial centers for remote sensing, such as the Ontario Center for Remote Sensing (OCRS), and from the user agencies.

International Cooperation and Consortia.

The Canadian earth observations program has been involved in a large number of international cooperative efforts, in particular with other satellite producing countries such as the European Space Agency (ESA, for the ERS and E-POP Programs), France (SPOT Program), Japan (NASDA, RESTEC, ERSDAC for the MOS and JERS Programs), and the United States (Landsat, NOAA, N-POP, and SEASAT Programs), and others. These programs have involved satellite program development, international earth observations applications development, and international data distribution. A major example is the participation of Canada through CCRS and CSA as an associate member of the European Space Agency's ERS-1 Program, an international consortia. This participation includes Canadian funding, planning, development, and data sharing. The development of the Canadian ERS ground data receiving and processing facility will allow Canada to share in ERS data receiving and distribution. But, this station is also the basis for the upgraded facility that will handle RADARSAT data.

Other cooperative programs include CCRS programs with NASDA/RESTEC in Japan utilizing the Canadian airborne radar to simulate JERS radar development. A number of other international cooperative applications and remote sensing development programs and projects have been conducted through OCRS with government agencies in countries such as the Asian countries (Indonesia, Malaysia, Thailand), Brazil, China, India, Norway and Peru. Many of these international programs and projects including the development of international remote sensing centers are supported by the International Research Development Center (IRDC) and the Canadian International Development Agency (CIDA). International marketing is provided through RSI with the assistance of CCRS and numerous Canadian value-added and services companies (see Appendix C-1).

National Education and Training Programs

By Canadian law, education is legally a Province issue. Therefore, primary role for earth observations education is conducted through the provincial centers for remote sensing and through university centers and programs with the support and assistance of CCRS. Major university earth observation education programs are located at the College for Geographical Sciences, Nova Scotia, Laval University, Sherbrooke University, the University of Waterloo, and the University of British Columbia. Many other universities and colleges offer courses in earth observations. Training programs are conducted through CCRS, the provincial centers, user agencies, and by value-added/service companies. International education and training is conducted by CCRS, provincial centers for remote sensing, and private sector companies through the IDRC and CIDA, as well as the World Bank and various agencies of the United Nations.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The Canadian earth observations program has passed through the R&D stage and into the pre-launch Testing and Verification stage for the RADARSAT satellite, with launch scheduled for 1994. However, Canadian progress in pre-launch applications development, demonstration projects and commercial product and services development is well on the way to producing a viable market for RADARSAT data by the time of its scheduled launch. This pre-launch market development for the RADARSAT Program is unique among countries currently planning their first operational earth observation satellite system.

Research and Development.

During the early 1970's, the Ministry for Energy, Minerals, and Resources established the Canadian Center for Remote Sensing (CCRS) to help the development of the use of this new technology for resource management and later environmental monitoring. These early programs were closely coordinated with R&D programs in the United States with NOAA, Landsat, and SEASAT satellite and Shuttle Imaging Radar (SIR-A, -B) data, and later with French SPOT and Japanese MOS data. During the late 1970's, with the continued push for petroleum exploration and development in northern Canada and the Arctic, and with the perceived need to expand Northwest Passage petroleum transport and development by ship, the Canadian government decided to develop an all-weather radar satellite to penetrate cloud cover and provide Canadian government and industry with ocean and ice monitoring information in northern Canada. R&D with SEASAT, SIR, and airborne radar data further convinced the government that such a radar satellite would also provide useful land information and global intelligence and would strongly compliment electro-optical sensing satellites planned in other countries. This research and these deliberations led Canada to become an Associate Member of the ESA ERS program and to plan for a Canadian RADARSAT Program. R&D for RADARSAT has been conducted by CCRS, the provincial centers for remote sensing, international cooperative research, academia, and industry, such as MacDonald Dettwiler (MDA), developer of synthetic aperture radar (SAR), and Intera, experienced in airborne radar applications. Through these R&D efforts, the unique RADARSAT satellite system was designed.

Testing and Verification.

Studies by the agencies above continue to simulate and evaluate the RADARSAT sensor and satellite system. Pre-launch testing and verification are currently being continued.

Applications Development and Demonstration Projects.

Pre-launch applications development and demonstration projects, as described above, are being conducted across a broad range of government and industry earth observations users. In addition to the CCRS User Assistance and Market Unit and the CCRS Technology Transfer Section, several other earth observations application and commercial development centers have been established. Some of these include the Fisheries and Oceans Center at Pat Bay, Victoria, the Petawawa Natural Forestry Institute, Chalk River, Ontario, and the provincial centers such as the Ontario Center for Remote Sensing (OCRS) and the Alberta Center for Remote Sensing(ACRS).

Commercial Products and Services

Commercial products and services have been under development by the growing Canadian earth observations value-added and services industry spawned in part by the Applications Research Programs, Demonstration and Pilot Projects, and the Contract Joint Government-Industry Applications Research described previously. These programs have been conducted through CCRS, the provincial centers for remote sensing, and the user agencies at the application and commercial development centers above. The contract joint government-industry applications research, in particular, has served to subsidize, or stimulate, the growth of the value-added and services industry and to develop commercial products and services. This is shown in part by the growth rate of such companies in Canada as follows:

early 1970's	5/6 companies
1984	34 companies
1987	73 companies
1989	112 companies

NATIONAL EARTH OBSERVATIONS PROGRAMS

EUROPEAN SPACE AGENCY (ESA)

ORGANIZATIONS DEVELOPING EARTH OBSERVATION PROGRAMS

The earth observations programs of the European Space Agency (ESA) include the operational meteorological Meteosat program. The oceanographic and land observing Earth Resources Satellite (ERS-1 and 2) Program under development for a 1990 launch, and the European Polar Orbiting Platform Program (E-POP-1 and 2) currently being planned for 1997 and beyond. Of principle interest for commercial applications during the 1990's is the ERS Program, although some proposed E-POP data could have commercial potential by the end of the decade. The ERS Program is nearing final preparations for launching in 1990. The program is presently going through pre-launch testing and applications development. Plans for data policy, demonstration projects, education and training, and commercial development will be finalized in early 1990.

ESA is an international consortia of fifteen countries represented by their space agencies or organizations. Member countries include Austria, Belgium, Denmark, Federal Republic of Germany, France, Ireland, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom, with Canada and Finland as associate members. Membership ownership (voting rights) is a function of the percentage of the ESA budget contributions by each country. Listed in order of member percentages, they are in 1990: France (30%), FRG (24%), Italy (14.8%), United Kingdom (6.4%), Belgium (4.6%), Spain (4.1%), The Netherlands (2.6%), Sweden (2.3%), Switzerland (2.3%), Austria (0.9%), Denmark (0.9%), Norway (0.8%), Canada (0.7%), Finland (0.4%), and Ireland (0.3%). International policy and program direction originates from the ESA Council and is administered by the Director General (DG) through several program boards (i.e., Specialized Programs) and administrative committees (i.e., Science Programs, Administration and Finance, International Relations, Industry Policy, Earth Observations Directorate, etc.). ESA operates through four major entities: ESA Headquarters (HQ), in Paris, France; the European Space Research and Technology Center (ESTEC) in Noordwijk, The Netherlands; the

The 112 companies, while less than the estimated 200-300 companies in the United State, still represents one third of all non-U.S. earth observations value-added/services companies worldwide. International marketing priorities for these Canadian companies are the U.S., Asia, Middle-East, Europe, India, South America, and Africa. Promotion of this commercial development has been assisted by CCRS, CIDA, IDRC, the Canadian Institute for Surveying and Mapping (CISM) and the Geomatics Industry Association of Canada (GIAC).

ANALYSIS AND PROJECTION

The Canadian national RADARSAT earth observations program is moving rapidly towards commercial development,with an established market prior to its launch in 1994. Because RADARSAT is a mixed operational government and commercial program with a significant portion of its data distribution to the national and international government partners, RADARSAT will not become fully commercial during its 5-year life time. However, because of the uniqueness of the RADARSAT data its complimentary compatibility with other international satellite data, and the current, rapid development of a pre-launch national and international market by CCRS, the provincial centers for remote sensing, and the designated private sector commercial marketing organization RSI, that segment of data available for commercial sale should reach full commerciality early in the life of RADARSAT and provide some pay back for the satellite system itself. RADARSAT, through RSI, will become a major provider of commercial satellite radar earth observation data worldwide. The success of the RADARSAT Program in providing the Canadian government and industry with both operational and commercial data is a testament to the unique government-industry cooperation and partnership in the Canadian national earth observations program from planning and implementation.

European Space Operations Center (ESOC) in Darmstadt, FRG.; and the European Space Research Institute (ESRIN), in Frascati, Italy. ESA conducts several space programs in addition to earth observations. These include SPACELAB and COLUMBUS space station programs, EURECA, the European Retrievable Carrier, and deep space, telecommunications and meteorology experimental, exploratory, and operational satellite programs.

Research and development for ESA earth observation programs have been conducted at both ESTEC, ESRIN, and ESA HQ as well as through space organizations of the member states. After initial R&D by ESA, the operational Meteosat Program was turned over to an international operator, EUMETSAT, a mechanism which could be a model for operational development of the ERS program. During the development of the ERS program and through its international agreements with NASA and NOAA in the U.S. ESA/ESRIN developed EARTHNET, an earth observation data receiving, processing, and research and commercial distribution network for Meteosat, Landsat and other international satellite data. ESRIN operates the Information Retrieval Service (IRS) for automated documentation retrieval and the European Documentation Service (EDS). In 1988, the data processing, and commercial distribution of Landsat data for ESA was turned over to a private sector operator, Eurimage, owned by Hunting Technical Service (U.K.), Spot Image (France), Telespazio (Italy) Satimage (Sweden), and DFVLR (Germany).

ERS pre-launch research, testing, and applications development studies have been directed by ESA/HQ, ESTEC, and ESRIN. Current planning for ERS data policy, technology demonstration and commercial development for ERS data is being directed by ESA/HQ and ESRIN. Under present plans, ESA/HQ, ESOC and ESRIN will oversee worldwide data reception by international ground stations as well as primary ESA ground stations at Kiruna Sweden, Maspalomas, Spain, Tromso, Norway, and West Freugh, U.K. for tape recorded data. Ground receiving under ESA/ESOC will be through DAPF's (Data Acquisition and Processing Facilities) and RDAF's (Realtime Data Acquisition Facilities) in member and other cooperating ground receiving countries. Archiving will be conducted under ESA/ESRIN at PAF's, (Processing and Archiving Facilities) at DFVLR, Oberfaffenhofen, FRG., IFREMER, Brest, France, RAF, Farnborough, U.K. and Telespazio, Fucino, Italy. The global data distribution network under ESA/ESRIN will be through international agreements for research data and through a commercial data marketing and sales organization modeled after the French Spot Image organization.

ANALYSIS

The radar, wind scatterometer, and altimeter data produced by the ERS program was designed initially as an experimental research satellite program preceding proposed ESA polar orbiting platform programs for the space station era in the late 1990's. ERS data was designed primarily for all weather coastal pollution, ocean and polar ice remote sensing and ESA technology demonstration. However, sensor specifics, while designed as experimental systems, were also designed to measure useful parameters. The potential utility of the ERS C-band radar and other sensor data for ocean, ice, land, and pollution mapping have caused ESA's management to speed up the originally planned ERS-1 to -2 transition from experimental to commercial operations to be transitional during the life of ERS-1. In December 1989, a data policy for both experimental research data and commercial data sales was proposed by ESA/ESRIN to the ESA Council to be implemented in 1990. The ERS Program will develop an active commercial market for ERS data during the life of ERS-1, 1990-1993, and should become fully commercial for the ground segment (data receiving, processing, distribution, and marketing) during the life of ERS-2, 1994-1997.

PROGRAMS AND PROJECTS

ESA's development of the meteorological earth observations METEOSAT Program reached the operational stage with the initiation of the Meteosat Operational Program with MOP-1, which replaced the METEOSAT-3 satellite in 1989. This program was then turned over to EUMETSAT, the European Organization of Meteorological Satellites with 16 member states. The ERS program has reached the pre-launch development stage with pre-launch design verification and applications simulation studies both within the ESA organization and member states and with cooperating international government research organizations and other potential users.

National Research and Commercial Development Programs

Basic research and development for the ERS program was initially conducted by ESA/HQ and ESTEC. ESTEC and ESRIN developed the initial pre-launch ERS-1 simulation studies.

These studies were conducted under an Announcement of Opportunity (AO) in 1986. Various research organizations from member states, cooperating international government agencies such as NASA and NOAA in the U.S., NASDA in Japan, and CCRS in Canada, and some other user organizations including some from the private sector were selected as principal investigators. Research projects consisted of a wide variety of simulation studies for ocean, ice, land and pollution mapping applications. These studies consisted of utilizing existing airborne and satellite radar, altimeter, and ocean color imaging sensors. The results of these studies have yet to be completed and published. Basic and applied R&D is also conducted at the Joint Research Center (JRC) at Ispra, Italy.

In conjunction with the current establishment of the ESA ERS data policy, a program of additional AO research projects and other user demonstration projects utilizing early post 1990 launch ERS data is being organized under ESA/ESRIN. This research will be organized before the ERS launch late in 1990. Similarly, ESA/ESRIN is in the process of organizing a technical marketing and commercial development organization to succeed the previous distribution systems under EARTHNET, as supplemented by EURIMAGE, and patterned after the Spot Image Corporation. This commercial organization will probably be an E.I.G. (Economic Interest Group) to be initiated in 1990.

The ESA Earth Observation Preparatory Program (EOPP) is actively preparing for E-POP-1 by developing The Meteosat Second Generation, the Solid Earth Mission (Aristoteles gravity satellite), and the Polar Orbit Earth Observation Projects. Ground research with airborne sensors is conducted as the European Imaging Spectroscopy Campaign (EISAC) under the direction of the Joint Research Center (JRC) at Ispra, Italy, and in joint airborne SAR applications with NASA/JPL.

International Cooperation and Consortia

As previously stated, ESA is an international consortia of 15 member countries. The Meteosat program was developed and operates under several international advisory groups and research and operational meteorological consortia such as the World Climate Research Program (WCRP), the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC), the International Council of Scientific Unions (ICSU) and the Committee for Space Research (COSPAR). Programs under these cooperative efforts include the International Satellite Cloud Climatology Project (ISSCP), the Tropical Ocean and Global Atmosphere study (TOGA), the World Ocean Circulation Experiment (WOCE) and the International Satellite Land Surface Climatology Project (ISLSCP). International cooperation between ESA and these organizations applies to the Meteosat programs and will involve the ERS program. These programs operate under data policy for equal access and reciprocity of research data. These studies will continue to involve ESA in programs such as exchange of NOAA operational TIROS data, data from the US-French TOPEX/POSEIDON program. Mechanisms for international cooperation between ESA and other international governmental agencies include ESA participation in the International Polar-Orbiting Meteorological Satellite Group (IPOMS), the Coordination of Geostationary Meteorological Satellites (CGMS), the Committee on Earth Observations Satellites (CEO), the International Forum on Earth Observations using Space Station Elements (IFEOS), and the International Coordination Working Group (ICWG) of Space Station Partners on the use of Polar Orbiting Platforms for Earth Observations.

For the ERS program, international cooperation to present consists primarily of international participation in the pre-launch AO ERS simulation studies as described above.

National Education and Training Programs

Education and training programs for the ERS-1 program are presently under planning consideration at ESA/ESRIN for implementation after the ERS launch in late 1990. Pre-launch ERS-1 education and training programs are is conducted at the JRC, Ispra, Italy.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The ESA earth observation program consists of the Meteosat, ERS, and European Polar Orbiting Platform (E-POP) systems. Meteosat has passed through the R&D, Testing and Verification, and Applications Development and Demonstration Projects stages and is presently an operating system providing international, non-commercial meteorological data services. The ERS program has the completed R&D stage and is passing through the pre-launch testing and verification stage into the applications development stage. The E-POP system is in the early R&D planning stage.

Research and Development

Research and development for the Meteosat, ERS and E-POP systems has been and is the responsibility of ESA/HQ and ESTEC in cooperation with space agencies of ESA member states. ESA, itself, was initiated in 1973 from the earlier European Space Research Organization (ESRO) and European Launcher Development Organization (ELDO), both begun in 1964. R&D for Meteosat preceded its initial launch in 1978 while R&D for ERS has been conducted during the mid-1980's largely at ESTEC, who has the responsibility for the study, design, development, and testing of new spacecraft. ERS was designed as a government experimental system with radar, altimeter, and wind scatterometer sensors that would compliment the present electro-optical international earth observation satellites such as IRS, MOS, Landsat, Meteosat, NOAA, Spot and TIROS. The ERS radar will be the first civilian, global satellite sensor to routinely penetrate the earth's cloud cover and provide real-time ocean, ice, land and pollution data independent of the weather. R&D is currently being conducted by ESA/HQ and ESTEC with other polar-orbiting platform producing countries (i.e., Japan, and the U.S.) in planning and designing the E-POP system with many atmospheric, land, and ocean sensors for broad earth systems science study.

Testing and Verification

In 1986, ESA/ESTEC and ESRIN initiated the pre-launch verification and applications development ERS simulation studies program as described in national programs above. These studies from numerous international principal investigators are using various sources of airborne and satellite remote sensing data such as NOAA and Meteosat, AVHRR and ocean color type data, NASDA MOS oceanographic microwave data, NASA and CCRS radar data, etc. These data are being used to conduct scientific research and applications development studies for real-time ocean, ice, land and pollution mapping and monitoring. The results of these simulation studies should be completed and published in 1990.

Applications Development and Demonstrations Projects

Subsequent to the results of the pre-launch simulation studies above and the data policy finalization in early 1990, ESA/ESRIN is planning a second ERS applications development and demonstration series of studies utilizing new ERS data. These studies will emphasize applications for weather and sea-state forecasting, ice mapping and monitoring, ocean imaging, land topographic, geologic, and vegetation mapping, and commercial offshore uses such as oil/gas exploration and engineering, ship routing and fishing. As with the French PEPS studies, this program to provide potential users with new satellite data to work with should help establish a user market for ERS data for commercial as well as research data. Additional demonstration projects pilot projects, and education and training are presently being planned by ESRIN.

Commercial Products and Services

The Meteosat Program is fully operational and operating under EUMETSAT. It provides non-commercial meteorological data and services, but some of the spectral data may be used in commercial information services such as television and other commercial weather and ocean information services by the private sector.

Data policy and implementation planning for the development of commercial ERS products and services is currently being conducted by ESA/HQ, ESRIN, and the ESA Council. Establishment of a commercial entity for ERS data should occur in 1990. Such a commercial entity will work with the newly formed European Association of Remote Sensing Companies (EARSC), The European Association of Remote Sensing Laboratories (EARSel), and other users to develop the value-added and information services industry market for ERS data. This commercial activity will also probably develop a commercial market for some of the more useful earth observation data from the E-POP program in the late 1990's.

ANALYSIS AND PROJECTION

ESA has demonstrated a successful earth observation program with the development of the Meteosat system from R&D through to fully operational, though non-commercial, services and products under EUMETSAT. The ERS and later E-POP systems were initially designed as research and experimental system, without commitment to commercial development. However, the recent decisions of ESA management to develop commercial access to the ERS program while still satisfying the original ERS research plans remains to be demonstrated. Dual research and commercial development of satellite systems has been shown by Landsat and Spot to be difficult at best. However, the utilitarian nature of the ERS data, coupled with its unique characteristics complimentary to other satellite program data, along with a strongly developing international earth observation market, should provide for successful commercialization of the ERS ground segment by the time of the planned ERS-2 launch in 1994. The successful commercialization of ERS data will depend on ESA's commitment to continued subsidy of the space segment through ERS-2 and to resolve the dual research and commercial nature of program.

NATIONAL EARTH OBSERVATIONS PROGRAM

BRAZIL

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

The Brazilian national earth observations program is based on a long established and well developed ground segment for data reception, archiving, processing and distribution of Landsat and SPOT and other non-Brazilian satellite data to government and commercial users. The Brazilian program has recently been expanded to include plans for a joint Brazilian-Chinese (PRC) earth observing satellite competitive with Landsat Thematic Mapper-SPOT capabilities. This satellite, the CBERS (China-Brazil Earth Resources Satellite), is scheduled for a 1993 launch. The principal organization responsible for the Brazilian earth observations programs is INPE (Instituto de Prequisas Espacias), the Institute for Space Research of Brazil.

INPE operates under the direction of the Special Secretary for Science and Technology (SECT) through the policy guidance of COBAE, the Brazilian Committee on Space Activities. INPE is headquartered at San Jose dos Campos, Sao Paulo, and operates the Brazilian ground station at Cuiaba. Basic R&D, applications development, marketing, education and training and user interface is provided by INPE's Technical Orientation Center in Remote Sensing (TOC). Applied R&D is conducted by INPE/TOC and INPE's R&D Remote Sensing Department. Image processing and data management is under the Image Processing Department (IPD) and the Remote Sensing and Imaging Processing Center (NCE). INPE conducts education and training programs and markets Landsat and SPOT data under international agreements to the general user community.

The development of a Brazilian user market by INPE has been assisted by user agencies, an association of regional remote sensing laboratories, universities and several private sector value-added and service companies.

The China-Brazil Earth Resources Satellite (CBERS) Program is a joint venture program between INPE of Brazil, and CAST, the Chinese Academy of Science and Technology, of the Peoples Republic of China (PRC). This joint venture program unites Brazil's technical capabilities in sensor development and long term experience in earth observations applications, development and marketing and Brazil's equatorial location with China's launching capabilities (Long March systems), satellite experience, and need for an equatorial launch site capability.

ANALYSIS

The current Brazilian earth observations program is a well established ground segment program for domestic consumption based on international agreements for satellite data. The development of the planned CBERS program would give Brazil and the PRC their own source of Landsat - SPOT type data for national needs and for international economic and political intelligence beginning in 1993. At present, it is not clear whether Brazil and the PRC will exploit the CBERS data for commercial purposes, but the data will have commercial potential to supplement mid-1990 Landsat - SPOT data markets.

PROGRAMS AND PROJECTS

The Brazilian earth observations program has been developed through several research, development, and applications programs under INPE with various Brazilian organizations and through international cooperative programs.

National Research and Commercial Development Programs

Basic research in earth observations is conducted under INPE through its Technology Orientation Center (TOC) and R&D Remote Sensing Department with user agencies, universities, associated remote sensing laboratories, and the Foundation for Space R&D and Applications (FUNCATE). Funding support for basic research is supplied by the Brazilian Funding for Projects and Studies (FINEP), the Brazilian Council for Science and Technology Development (CNPQ), and the Sao Paulo State Research Fund (FAPSEP). Applied earth observations research is conducted through several agencies and organizations with various government and industrial users.

An example of these programs is the SPOT Applications Program (PAS) run by INPE with the cooperation of the French Spot Image Corporation. Private sector programs include the Private SPOT Distribution Network by ANEA, the Brazilian Association of Air Surveyors, and the Remote Sensing of Natural Resources Program conducted by Sensora.

International Cooperation and Consortia

International cooperation by INPE includes its international agreements to process and distribute data through INPE's ground segment facilities. These cooperative agreements include those with France's CNES for SPOT data, EOSAT/NOAA for Landsat and NOAA/GOES data, ESA for Meteosat data, and SARSAT/COSPAS for international Search and Rescue Satellites. Agreements have been made to receive and distribute future data from ESA's ERS and Canada's RADARSAT programs. Brazil conducts cooperative programs with Ecuador's CLIRSEN for SPOT and Landsat data processing and distribution and with SELPER, the South American Remote Sensing Society which supports the general development and promotion of earth observations applications. INPE conducts cooperative research with NASA in the EOS Joint Research Program and with Japan's NASDA and ERSDAC for joint geologic remote sensing studies.

The agreement between Brazil and the People's Republic of China (PRC) to build the CBRES China-Brazil Earth Resources Satellite will create a Chinese-Brazilian earth observation consortia. This consortia will be jointly run by INPE and CAST (the China Academy of Science and Technology). Another cooperative agreement between China and Brazil is the recent formation of INSCOM, a commercial joint venture between Aribra Aerospacia of Brazil and the Great Wall Industry Company of the PRC. INSCOM was created to jointly develop launch facilities and services, earth stations, and communications and remote sensing satellites.

National Education and Training Programs

Government earth observations education and training programs are conducted by INPE with FAPESP (San Paulo) and CAPES. Academic programs are conducted through INPE's Graduate Remote Sensing Program and at the University of Brazilia (Geologic Remote Sensing), University of Campines (CEPAGRI), FUNCEME (Hydrology and water resources), and in other university programs. Private sector education and training programs are conducted by Sensora (hand-on-training), FUNCATE (image analysis), Imagen (hands-on-training), among others. International education and training programs are conducted by INPE and by the Remote Sensing Research Center at Porto Alegre for users from Latin-American and other developing countries.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The Brazilian national earth observations program has established a well organized operational ground segment for developing a national government and industrial market for earth observation data provided by non-Brazilian international satellite programs. This market development has been accomplished by INPE in cooperation with user agencies, industry and academia through research and development, applications development and demonstration projects and education and training programs.

Research and Development

Research and development for earth observations programs are conducted by INPE through its Technology Orientation Center TOC. INPE's R&D has been conducted with international cooperation from countries providing satellite data for reception and distribution through INPE. These include NASA and NOAA in the U.S., CNES and Spot Image in France, NASDA, RESTEC, and ERSDAC in Japan, CCRS in Canada, and ESA in Europe. R&D for the CBERS is being coordinated by INPE with CAST in China.

Testing and Verification

The CBERS Program is currently in the planning stage and will include a Testing and Verification Stage.

Applications Development and Demonstration Projects

INPE has conducted numerous applications development and demonstration projects with government and industry users. Some of these include resources companies such as Petrobras (oil), CVRD and CPRM (mining), development organizations such as SUDAM (Amazon), SUDENE (Northeast) and EMBRAPA (Crop and Range Land), and IBAMA, the Brazilian Institute of Environment. INPE cooperative application and demonstration projects include the following.

Underwater mapping - Brazilian Divers Association
Landsat spectral temporal matching - EMPLASA (San Paulo)
SPOT merging for urban studies - Engespaco (Space Engineering)
Amazon Forestry Atlas - FUNCATE (Foundation for Space R&D and application)
Atlantic Rain Forest Atlas - SOS Mata Atlantica (Atlantic Forest Foundation)
Land Assessment and GIS Cadaster - INCRA (Brazilian Institute for New Humane Settlements)

Commercial Products and Services

Commercial products and services for ground receiving, processing, archiving, distribution and value-added services have been developed through INPE with various users organizations and with private industry. Some of these organizations include the following:

Ground receiving and data processing - INPE, Engespaco, Amplimatic Antennas, ANEA, Sensors, Terrafoto

Space Systems - INPE, IAE (Army Institute of Space Activities), Embraer (Brazilian Aeronautice Co.), Orbita Co. (Space Systems engineering)
Image Processing and GIS - INPE, Aerosul, Aerodata, EMBRAPA, Engespaco, Esteio, Sensors, and INPE's Associate Remote Sensing Labs.
Value-Added Services - Aerofote Cruzeiro, FUNCATE, Imagen, Petrobras, Prospec, and others.

ANALYSIS AND PROJECTION

The Brazilian national earth observations program has developed a well organized and operational ground segment system for international satellite data for government use and commercial development through INPE. Brazil's plans to develop the CBRES earth observations satellite with the PRC will provide Brazil with its own source of global earth observations data. At present, Brazil and the PRC have not decided whether to commercially exploit the CBRES data on a global basis and do not have an international commercial marketing entity. But planned CBRES data will be similar to Landsat Thematic Mapper and SPOT data and thus has commercial potential. CBERS data will impact international markets for Landsat and SPOT earth observations data.

NATIONAL EARTH OBSERVATIONS PROGRAM

INDIA

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

The Indian national earth observations programs have produced an operational meteorology satellite system, INSAT-1, and an operational land observing satellite, IRS-1A (Indian Remote Sensing Mission), with nationally integrated ground receiving, data management and information systems. These systems are part of the Indian Space Program under the Indian Department of Space (DOS) to develop a national remote sensing system for resource survey and management, environmental monitoring and meteorological services leading to an operational geographical and weather information system for India. VOSTOK launch and other technical assistance was provided by the Soviet Union through Glavcosmos and other Soviet agencies. The Indian program is designed to serve India and is not presently planned for commercialization or as an international intelligence gathering system.

The Indian earth observations programs are part of the Department of Space, Bangalore. There are five main elements of the Department of Space, which are: the Indian Space Research Organization (ISRO), the Indian National Satellite Space Segment Project (INSAT-SPP, meteorology), the National Natural Resources Management System (NNRMS), the National Remote Sensing Agency (NRSA), and the Physical Research Laboratory (PRL).

The Indian Space Research Organization provides for the technology development, operations, and applications for the programs through several ISRO departments or organizations through the ISRO Headquarters at Bangalore as follow.

ISRO Satellite Center (ISAC), Bangalore, conducts spacecraft development, launch vehicle interface, mission planning and project management.

Spacecraft internal systems are developed at the Vikram Sarabhai Space Center (VSSC), at Trivandrum.

ISRO Telemetry, Tracking And Command (TTC) is operated from the center (ISTRAC) at Bangalore and from a TTC station at Lucknow.

The ISRO Space Applications Center (SAC) at Ahmedabad develops image sensors and data products systems, and oversees the IRS Utilization Project (IUP).

The National Remote Sensing Agency (NRSA), Shadnagar, Hyderabad, operates the data reception station and the data processing, data products and archiving systems. NRSA oversees the data distribution system and is the agency responsible for national and international (non-commercial) data sales.

The National Natural Resources Management System (NNRMS) Secretariat is located at Bangalore. It operates Regional Remote Sensing Services Centers (RRSSC) at Dehra Dun (northern center), Jodhpur (western center), Kharagpur (eastern center), and Nagpur (central center). NNRMS's role is to integrate satellite based remote sensing with conventional data systems for resource management in order to operate a national geographical information system.

The National Satellite Space Segment Project (INSAT-1-SSP) operates India's meteorological satellite program utilizing the INSAT-1 satellite.

The Federation on Remote Sensing Companies of India (FORCI) is an organization of private sector companies developing remote sensing systems, applications and value-added services.

ANALYSIS

The national earth observations programs of India are programs designed to service national domestic needs without commercialization. Data from the IRS-1A and planned IRS-1B and IRS-1C satellites have commercial potential, but at present, there are no commercial earth observations development programs in India.

PROGRAMS AND PROJECTS

While there are no commercial earth observations programs in India at present, the various agencies above conduct several research, applications and development programs, such as the following examples.

National Research and Non-commercial Development Programs

Basic research and development for earth observations has been conducted by the Indian Space Research Organization (ISRO) at its Headquarters, in Bangalore, and at the Space Applications Center (SAC) in Ahmedabad. R&D by ISRO has been done with the Physical Research Laboratory (PRL) and with various user agencies and academic centers. These programs include the following.

Joint Experiment Program (JEP). Extensive airborne, experimental satellite, (BHASKARA I & II) Landsat and Spot studies were conducted with user agencies to establish requirements and simulate the IRS program before its launch in 1988. These studies laid the foundation for the establishment of the National Natural Resources Management Services System (NNRMS).

IRS Utilization Project (IUP). The IUP was established by the NNRMS working with the ISRO Space Application Center (SAC) to effectively use IRS data in applications for agriculture, hydrology, geology and to provide a comprehensive data base for NNRMS.

Remote Sensing Application Mission for Drought. The ISRO/SAC and the National Remote Sensing Agency (NRSA) have conducted studies using satellite monitoring for droughts under the Remote Sensing Application Mission for Drought. These studies have lead to the formation of the National Agricultural Drought Assessment and Monitoring system (ADAMS) by NRSA, the India Meteorological Department (IMD), the Central Water Commission (CWC), various state government agencies, and the Ministry of Agriculture. ADAMS utilizes NOAA AVHRR as well as Landsat, SPOT and IRS data.

International Cooperation and Consortia

The Indian earth observations program has not been noted for its full international cooperation in the past. Many countries have experienced difficulties obtaining INSAT-1 and Landsat data received in India. However, with the advent of IRS-1A satellite system and the completion of the IRS ground segment, international data users should experience better access to Indian data. The Indian program does have close technical support and cooperation from the Soviet Union. This includes VOSTOK launch services and other technical assistance. India also cooperated with the West German space agency, DFVLR, in an unsuccessful attempt to launch the German STEREOMOMS earth observations sensor system in 1988.

National Education and Training Programs

Indian earth observation education programs are conducted under the ISRO Development and Educational Communication Unit (DECU) and coordinated with the NNRMS Regional Remote Sensing Service Centers (RRSSC's), user agencies and university centers.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The Indian earth observation programs have completed the research and development and the testing and verification phases and have passed into the applications and demonstration phase of operational programs. The IRS-1A program is developing user products and services, but for national governmental uses and not for commercialization.

Research and Development

The Department of Space and the overseeing Space Commission were created in 1972 which lead to the establishment of ISRO. Based on national needs for optimal natural resources management, ISRO established R&D studies under the Joint Experiment Programs listed above with various government user agencies. R&D for the IRS-1A satellite was conducted by ISRO, the Physical Research Laboratory (PRL) and the Vikram Sarabhai Space Center.

Testing and Verification

Testing and verification for the IRS-1A were carried out by the same agencies above.

Applications Development and Demonstration Projects

Applications development for the IRS-1A has been conducted by the ISRO Applications Center (SAC) and by the ISRO DECU (Development and Educational Communication Unit) with cooperating user agencies. Particular among these is the IRS Utilization Project (IUP) under the National Natural Resources Management System (NNRMS). Specific demonstration projects with user agencies and industrial users are conducted by the ISRO Technology Transfer Group.

Commercial Products and Services

The Indian earth observation program is designed to provide India with data for national operational geographic and weather information systems. NRSA has created IRS-1A data products and services which are used by government user agencies and others. These data products are generally comparable to Landsat and SPOT data sets and have commercial potential for a future marketing organization should one be developed. Present data products are being offered at non-commercial direct material cost only, without royalties. Therefore, prices for IRS data are considerably lower than comparable commercial Landsat or SPOT data. IRS carries no tape recorder, but India will make IRS data available to foreign ground receiving stations that are upgraded under intergovernmental MOU's. IRS reception can be established by upgrading Landsat or SPOT receiving stations using relatively inexpensive Indian data processing equipment. ISRO has also developed image processing hardware and software to process IRS-1A data under the name ISROVISION. These systems will be available for sale to the international user community.

ANALYSIS AND PROJECTION

The Indian national earth observation program has developed sophisticated satellite systems for national information needs. The government plans to fund and operate the IRS-1B satellite and develop and operate the advanced IRS-1C satellite system with a sensor package similar to the Landsat Thematic Mapper. There are no plans at present to commercialize these systems. However, IRS-1A, -B, and -C data do have commercial potential on the open market and could be marketed through international ground receiving and marketing organizations.

NATIONAL EARTH OBSERVATIONS PROGRAMS

FEDERAL REPUBLIC OF GERMANY

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

The Federal Republic of Germany, FRG (West Germany), national earth observations programs have focused on the development of the Metric Camera flown on board NASA's Space Lab and the MOMS (Modular Optoelectronic Multispectral/Stereo Scanner) series of experimental sensor systems flown on board NASA's Shuttle. The primary earth observations organizations are the recently formed West German national space agency, DARA, and the German Aerospace and Research Establishment, DLR (previously, DLVFR). DARA and DLR are under the Ministry for Research and Technology, BMFT. German industry through MBB (Messerschmitt-Blokow-Blohm) attempted a commercial effort in 1983 to exploit MOMS-1 technology on a proprietary basis, which failed because NASA would not accept a proprietary earth observation mission for Shuttle.

The MOMS series of sensors was developed by MBB for the DLR/DLVFR to be mounted on board the German Shuttle Pallet Satellite Platform (SPAS) for flights on NASA's Shuttles. Two MOMS Missions (MOMS-1a and -1b) were flown on STS-7 and -11 in 1983 and 1984. An advanced series of MOMS stereo systems, MEOSS (Monocular Electro Optical Stereo Scanner), was initiated in 1987 with an unsuccessful attempt in India on board an ISRO (Indian Space Research Organization) launch vehicle which failed. MBB and DLR have developed the high resolution (5 and 15m) stereo MOMS-2 system to be flown on the D-2 Space Lab mission on a NASA Shuttle in 1991/2. DLR has developed earth observations systems and ground receiving and processing systems with MBB, Dornier, and other West German industry and academia, in particular, Munich University. West Germany, through DARA and DLR, is a member of the European Space Agency, ESA, and participates therein in the development of the ERS-1 radar satellite.

Analysis

The West German national earth observations programs have been experimental to date. At present, there are no known West German plans to develop a national commercial earth observations program, although MOMS-2 data will have commercial potential if later developed on a free-flying satellite with its stereo, high resolution data for automated cartographic and topographic mapping potential. 1/30/90

PROGRAMS AND PRODUCTS

West German earth observations programs and products are primarily those associated with the development of the MOMS program. At present, these efforts are directed towards applied research and experimental development of the MOMS system and not towards commercialization.

National Research and Commercial Development Programs

Basic earth observation research has been conducted through DLR, the German Aerospace and Research Establishment, under the direction of the Ministry of Research and Technology (BMFT). Basic and applied research has been conducted by DLR with other user agencies, MBB, Dornier, Munich University and other academic centers. Subsequent to the flights of MOMS-1a and -1b, DLR, MBB, and Munich University conducted a MOMS Evaluation program where user agencies, industry, and academia were provided MOMS data for applications and evaluation studies. These studies involved international participation including evaluations by the Geosat Committee. Similar user applications studies were conducted earlier for the Metric Camera.

International Cooperation and Consortia

West Germany participates as a member state in the European Space Agency, ESA, a fifteen country consortia which developed the meteorological Meteosat Satellite Program and is developing the radar ERS satellite and later EPOP polar orbiting platform programs in Europe. Other West German international cooperation includes the flying of the Metric Camera on NASA's Space Lab-1 Mission, the flying of MOMS-1a and -1b on NASA's STS 7 and

11, and the abortive mission to fly the first STEREOMOMS on an Indian launch vehicle. DLR is a partner in Eurimage, the international European commercial Landsat data distributor and value-added service organization.

National Education and Training

National earth observations education and training programs are conducted by DLR and Munich University and other academic centers.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The West German earth observations programs have been developed primarily as experimental and technology development programs. At present, there are no known plans for commercialization of the MOMS or other earth observations programs. As a member country, West Germany will share in the research and commercial development of the ESA ERS-1 and -2 programs for radar, altimetry, and wind scatterometer data. As an ESA member, West Germany will also participate through DARA in the development of the European Polar Orbiting (E-POP) Programs.

Research and Development

During the late 1970's, West Germany through the Ministry of Research and Technology (BMFT) decided to develop experimental earth observations technology with the Metric Camera and the MOMS-1a and -1b programs. Research and development was conducted under DLR with the aerospace industry led by MBB and Dornier and with Munich University and academic institutions.

Testing and Verification

Testing and verification of the Metric Camera and MOMS-1a and -1b systems was conducted by the organizations above. Development and testing of the MOMS-2 system is being conducted by MBB for DLR.

Applications Development and Demonstrations Projects

Application and demonstration programs for the MOMS-1a and -1b were conducted by DLR, MBB, Munich University and other user organizations. These programs included the MOMS evaluation program discussed above. Because there are no current plans for commercial development of the MOMS program, there are no applications development or demonstration projects being conducted for commercial purposes at present.

Commercial Products and Services

There are no West German national earth observations programs for commercial products and services being developed at present. However, the Digital Photogrammetric System (DPS) has been developed to utilize MOMS-2 data in the production of automated digital elevation models and topographic maps. Subsequent to the successful flights of MOMS-1a and -1b on Shuttles 7 and 11, MBB and others proposed a commercial program for follow-on MOMS missions. An international commercial partnership between MBB, COMSAT and Stembecl Reassiramce in the U.S., and others created the SPARX Corporation to fly a commercial MOMS mission for proprietary sale of MOMS data. This project was terminated in 1984 when NASA refused to fly the proprietary SPARX mission because it did not comply with U.S. policies of open skies and non-discriminatory access to data.

ANALYSIS AND PROJECTION

The West German national earth observations programs have demonstrated the technical development of experimental space borne earth observations opto-electrical sensor systems with the MOMS program. Commercial development of a polar-orbiting earth observations system remains to be demonstrated and no commercial development or sale organization is planned at present. However, the high spatial resolution, stereo, multispectral data of the MOMS-2 program has commercial potential for integration with other earth observations programs and for automatic topographic mapping with the DPS system.

NATIONAL EARTH OBSERVATION PROGRAMS

SOVIET UNION (USSR)

ORGANIZATIONS DEVELOPING EARTH OBSERVATIONS PROGRAMS

Until recently, the Soviet national earth observations programs have been basically closed or classified national programs for global military and economic intelligence. In 1989, the Soviet policy was changed to allow limited commercial distribution of some Soviet satellite data. This commercial distribution is currently limited to non-Soviet block countries or other countries not otherwise restricted by other Soviet political or economic interests (i.e., Argentina, Nicaragua, Peru, etc.). The Soviet programs open to distribution are based on film data, but future plans include electro-optical and radar sensor data. Only limited information on organizations, policy, technology, and commercialization plans were available for this report. Two primary parent Soviet organizations are providing, or plan to provide, Soviet satellite data in the next few years. These are Soyuskarta for film data and Glavkosmos for electro-optical data. Relations between these two organizations and other earth observation organizations in the Soviet Union are not well known at present.

Soyuzkarta is the data distribution subsidiary of the Soviet agency Priroda, the State Scientific - Research and Producing Center. Priroda is responsible for several years of film collection from a series of COSMOS satellites and from the MIR Space Station. This data is distributed in film and digitized film format by Soyuzkarta. In 1989, Soyuzkarta negotiated with a long time Soviet trading partner, the Continental Grain Corporation of New York, to establish a U.S. commercial distributor of Soyuzkarta data, ContiTrade Services, Inc.

Glavkosmos is the Soviet national agency responsible for the commercial development of space including launch services, space missions, and some forms of earth observations data. A U.S. company, Space Commerce Corporation, of Houston, Texas, has negotiated with Glavkosmos to act as the marketing agent for Glavkosmos services and products, including earth observations data, in the U.S. Little data has been made available yet, but Glavkosmos and Space Commerce Co. plan to provide digitzed film, electro-optical and radar data in the future.

ANALYSIS

The opening up of Soviet earth observation data to non-Soviet commercial distribution will impact the earth observations market during the 1990's. While present distribution is of limited quality (except for high spatial resolution of 3-5m) and quantity, the Soviet system has the potential to provide extensive archival film data and probably growing quantities of timely electro-optical and radar data in the future. With the tremendous changes presently taking place in the Soviet block countries and the USSR itself, it is difficult to assess how far international commercialization of Soviet earth observations will proceed, or how fast. But with growing East-West political and economic exchange and the Soviet need for Western currency, the establishment of a high-grade, western-style commercial organization for Soviet data could significantly impact the global earth observations markets.

PROGRAMS AND PROJECTS

Not much detailed information on specific Soviet earth observations programs or projects was available for this report.

National Research and Commercial Development Programs

Basic satellite and sensor R&D is conducted at the Institute of Space Devices for Glavkosmos systems and at the Photon Design Bureau. Research on earth observations applications is conducted at Priroda and through the All Union Foreign Trade Association V/O "Soyuskarta". Soyuskarta's main emphasis is in the fields of geodesy and cartography. Other earth observations basic and applied research is conducted through several Soviet user agencies in various disciplines. An example is research conducted by URCERE, the USSR Research Center for Earth Resources Exploration, for the exploration and development of energy and mineral resources. Meteorological R&D is conducted by the State Committee for Meteorology in Khabarosk.

Commercial development programs are presently limited to a few international trade shows in the U.S. and in England where Soyuzkarta and ContiTrade Service and Glavkosmos have demonstrated data products intended for sales outside the USSR. Inside the Soviet Union and the Soviet block and other countries with Soviet economic agreements such as Peru, Soyuzkarta operates as a commercial developer of their earth observations data. These efforts include consulting services, export of related technology and computer programs, instruments, products, and value-added services.

International Cooperation and Consortia

Soviet agencies developing earth observations technology have, until recently, provided cooperation largely only to Soviet block countries. Space agencies in countries such as Bulgaria and East Germany have participated extensively in earth observations research and development with their Soviet counterparts. The Soviet Union has provided considerable cooperation and technical assistance, including launch services, to the Indian earth observations and space programs. In addition to the opening of limited commercial access to Soviet earth observations data through U.S. marketing organizations, the Soviet Union signed cooperative science agreements with the U.S. in 1989. These agreements include cooperative science agreements with joint earth observations R&D to be conducted between NASA and Soviet earth observations agencies and academia.

National Education and Training Programs

National education and training programs are conducted by various state agencies and universities. Soyuzkarta conducts theoretical education and practical training programs to foreign specialists in the utilizations of earth observations data for topographic, geodetic, and cartographic applications.

COMMERCIAL STATUS OF THE NATIONAL PROGRAM

The Soviet earth observations programs has produced sophisticated operational satellite systems that serve national military and economic intelligence requirements.

Within the Soviet socialistic economic system, these programs service national users including the military, government agencies, academia, and industry. As such, these programs have variously passed through research and development, testing and verification, applications and demonstrations, and the development of products and services equivalent to commercial products and services in the Western world. What the Soviets have not as yet developed is a western-style commercial entity to compete internationally in the earth observations markets.

Research and Development

Research and development has been conducted by the user agencies, academia, and Priroda, Glavkosmos, URCERE (USSR Research Center for Earth Resources Exploration), and others.

Verification and Testing

As above.

Applications Development and Demonstration Projects

As above. Demonstration projects are conducted by Soyuzkarta and by Glavkosmos.

Commercial Products and Services

As above. Within the Soviet Union, earth observation products and services are developed by both Soyuzkarta and Glavkosmos. These include marketing, user interfacing, value-added services and consulting. User promotion is also supported by the newly formed Soviet Union Aeronautical Society which is organized like the American Institute for Aeronautics and Astronautics (AIAA) focusing on space programs in general, but including earth observations. In the new commercial efforts in the U.S., ContiTrade Services has begun distribution of limited amounts of Soyuskarta archival film products, and is taking orders for requested coverage from geographical areas not limited by Soyuzkarta. Glavkosmos data distribution through Space Commerce Co. has yet to begin.

ANALYSIS AND PROJECTION

It is premature to accurately project the commercial impact of Soviet earth observations programs on the world market. Soyuzkarta high resolution film data has a definite market niche for topographic, cartographic and geodetic applications. In addition, Soyuskarta data, when digitized, will find use in merging its high spatial resolution with multispectral data such as Landsat, SPOT or JERS data. Advanced electro-optical and radar data, if provided by Glavkosmos, could also be sold commercially. However, before Soviet earth observations data can make a significant impact on world markets in the 1990's, the Soviets must either set up, or negotiate with, a major sophisticated western-style commercial company to develop, command, and hold onto any significant part of the growing competitive global earth observations markets.

COUNTRY GLOSSARY: BRAZIL

ANCA	National Association of Aerial Surveyors
ANEA	Private SPOT Distribution Network
CAST	Chinese Academy for Science and Technology
CBERS	China-Brazil Earth Resources Satellite
CNPQ	Brazilian Council for Science and Technology Development
COBAE	Brazilian Committee on Space Activities
CPRM	Brazilian Mineral Resources Co.
CVRD	Vale do Rio Doce Co. (Steel)
Embraer	Brazilian Aeronautics Co.
EMBRAPA	Crop and Range Land Development Co.
FAPSEP	Sao Paulo State Research Fund
FINEP	Brazilian Funding of Projects and Studies
FIPEC	Brazilian Bank R&D Fund
FUNCATE	Foundation for Space R&D and Applications
IAE	Army Institute of Space Activities
IBAMA	Brazilian Institute of Environment
IMAGEN	Applied Remote Sensing
INCRA	National Agency for New Human Settlement
INPE	Institute for Space Research of Brazil (Instituto de Pesquisas Espacias)
/IPD	Image Processing Department
/TOC	Technical Orientation Center on Remote Sensing
NCE	Remote Sensing and Image Processing Center (Rio de Janeiro)
PAS	SPOT Applications Program
Petrobras	Brazilian Oil Co.

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SECT	Secretary Special for Science and Technology
SOS	Atlantic Forest Foundation
SUDAM	Amazon Development Agency
SUDENE	Northeastern Development Agency
UNESP	Center of Environmental Planning and Analysis , Rio Claro

COUNTRY GLOSSARY: CANADA

ACRS	Alberta Center for Remote Sensing
CACRS	Canadian Advisory Council on Remote Sensing
CCRS	Canadian Center for Remote Sensing
CIDA	Canadian International Development Agency
CISM	Canadian Institute for Surveying and Mapping
CSA	Canadian Space Agency
CSRS	Canadian Society for Remote Sensing
ERS	European Resources Satellite
ESA	European Space Agency
GIAC	Geomatics Industry Assocation of Canada
IDRC	International Development Research Center
Intera	Canadian airborne radar company
MCF	Missile Control Facility
MDA	MacDonald Dettwiler and Associates
MEMR	Ministry for Energy, Minerals, and Resources
MIST	Ministry of Industry, Science, and Technology
MMO	Mission Management Office
NSERC	National Sciences, Engineering Research Council
OCRS	Ontario Center for Remote Sensing
RADARSAT	Canadian radar satellite
RSI	Radarsat International, Inc., commercial distributor for Radarsat
SEASAT	U.S. NASA radar satellite, 1978
SIR	Shuttle Imaging Radar, NASA

COUNTRY GLOSSARY: **FEDERAL REPUBLIC OF GERMANY**

BMFT	Ministry for Research and Technology
DARA	Deutsche Agentur fur Raumfahrt-Angelegenhelten German Space Agency
DLR	Deutsche Forschungenstalt fur Luft and Raumfart (DFLVR) German Aerospace and Research Establishment
DPS	Digital Photogrammetric System
MBB	Messerschmitt-Blokow-Blohm GmbH
MEOSS	Monocular Electro Optical Stereo Scanner
MOMS	Modular Optoelectronic Multispectral/Stereo Scanner
SPAS	Shuttle Pallet Satellite Platform
USS	Unique Support Structure for D-2 Spacelab Mission

COUNTRY GLOSSARY: FRANCE

ACRES	Australian Centre for Remote Sensing
ARIANESPACE	French Aerospace Company; develops Ariane launch vehicle
AVAL	Joint CNES-Spot Image - user industry commercial demonstration and pilot project program
BDPA	Bureau pour le Development de la Production Agricole
BEICIP	Bureau d'Etudes Industrielles et de Cooperation de l'Institut Francais du Petrole
BRGM	Bureau de Recherches Geologiques et Minieres
CCCO	Committee on Climatic Changes and the Ocean
CEMAGREE	Centre National du Machinisme Agricole du Genie Rural des Eaux et Forests (hydrology and forestry)
CETEL	GDTA training course (9 months)
CNES	Centre National d'Etudes Spatiales
CNES CSG	CNES Centre Spatiale Guyanais
CNES CST	CNES Centre Spatiale de Toulouse
CNET	Centre National d'Etudes Telecommunications
CNRS	Centre National de la Recherche Scientifique
CRIS	Centre de Rectification des Images Spatiales
CRIS	South African Ground Receiving Station Agency
CRPE	Centre de Recherche en Physique de l'Environment
CST	Centre Scientifique et Technique
CURSETT	Ecuadorian Ground Station Agency
DGE	Delegue General a l'Espace
EARSeL	European Assocation of Remote Sensing Laboratories
EEC	European Economic Community
ELF AQUITANE	French petroleum company
ENGREF	Ecole Nationale du Genie Ruval des Eaux et Forets (hydrology and forestry)
ERS	European Resources Satellite
ESA	European Space Agency
FAO	Ministry of Foreign Affairs

FMO	French Meteorology Office
GDTA	Groupment pour le Development de la Teledetection
HELIOS	Joint French-Italian-Spanish military surveillance satellite
IFP	Institute Francais du Petrole
IFREMER	Institute Francais de Recherches pour l'Exloitation de la Mer
IGN	Institute Geographique National
INPE	Brazilian Remote Sensing Agency
INRA	Institute National de la Recherches Agronomique
INTESPACE	French space systems testing company
IOC	Intergovernmental Oceanographic Commission
KACST	Saudi Arabian ground receiving station agency
LERTS	Laboratory for Research in Space Remote Sensing
MATRA	French Aerospace Country
MS2i	Joint venture of Matra T2i and Sepimage SEP image processing companies
NASDA	National Aeronautics and Space Develoment Agency of Japan
NOVESPACE	French space commercialization promotional industrial group
NRCT	National Research Council, Thailand
NRSA	National Remote Sensing Agency, India
OSTROM	Office de la Recherche Scientifique et Technicique Outre Mer
PEPS	SPOT Early Assessment Program
PROSPACE	French Space Trade Association
RSC	GDTA remote sensing training course
SATIMAGE	Swedish Commercial Remote Sensing Company
SCOR	Scientific Committee on Ocean Research
SCOT COUNSEIL	Services de Consultance en l'Observation de la Terre, commercial subsidiary of CNES
SEP	French aerospace company
SERVICE ARGOS	Joint French-US marine positioning service

COUNTRY GLOSSARY: EUROPEAN SPACE AGENCY (ESA)

ARIANE	Arianespace launcher
AVHRR	Advanced Very High Radiometer Sensors (NOAA)
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination of Geostationary Meterological Satellites
COLUMBUS	ESA Space Station
COSPAR	Committee on Space Research
DAPC	Data Acquisition and Processing Center
EARSEL	European Association of Remote Sensing Laboratories
EARTHNET	ESA Ground Data Distribution Network
EDS	European Documentation Service (ESRIN)
E.I.G.	Economic Interest Group
EISAC	European Imaging Spectroscopy Campaign
ELDO	European Launcher Development Organization
EOPAG	ESA EOS Operations Plan Advisory Group
EOPP	ESA Earth Observation Preparatory Program
E-POP	European Polar Orbiting Platform
ERS	Earth Resources Satellite
ESA	European Space Agency
ESOC	European Space Operations Center
ESRIN	ESA European Space Research Institute
ESRO	European Space Research Organization
ESTRACK	Belgium Tracking Center
ESTRANGE	Swedish Tracking Center
ESTEC	ESA European Reasearch and Technology Center
EUMETSAT	European operator of Meteosat operations program
EURIMAGE	Commercial distributor of Landsat data for ESA
EURRCA	ESA Free Flying Platform
ICSU	International Council on Scientific Unions
ICWG	International Coordination Working Group of Space Station Parties using Polar-Orbiting Platforms for Earth Observations
IFEOS	International Forum on Earth Observations

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SICORP.	US subsidiary of Spot Image Corporation
SIG	GDTA remote sensing training course
SITAU	GDTA remote sensing training course
SITEL	GDTA remote sensing training course
SPOT	System Probatoire Observation de la Terre, French earth observation satellite
SPOT IMAGE	French commercial SPOT remote sensing company
SSC	Swedish Space Corporation
SUPARCO	Pakistan ground receiving station agency

IOC	Intergovernmental Oceanographic Commission
IPOMS	International Polar-Orbiting Meterological Satellite Group
IRS	Information Retreival System (ESRIN)
ISLSCP	International Satellite Land Surface Climatology Project
ISSCP	International Satellite Cloud Climatology Project
JRC	Joint Resarch Center, Ispra, Italy
METEOSAT	ESA Meterology Satellite
MOP	METEOSAT Operational Program
PAF	Processing and Archiving Facility
RDAF	Regional Data Acquisition Facility
TOGA	Tropical Ocean and Global Atmospheric Study
WCRP	World Climate Research Program
WMO	World Meterology Organization
WOCE	World Ocean Circulation Experiment

COUNTRY GLOSSARY: INDIA

ADAMS	National Agricultural Drought Assessment and Monitoring System
BHASKARA	Indian Experimental Satellite
CWC	Central Water Commission
DECU	ISRO Development and Educational Communication Unit
DOS	Department of Space
FORSCI	Federation of Remote Sensing Companies of India
IMD	Indian Meteorological Department
INSAT	Indian Meteorological Satellite
IPD PG RSA	Images Processing Developmental Products Group, ISRO/SAC
IRS	India Resources Satellite
ISAC	ISRO Satellite Center, Bangalore
ISRO	Indian Space Research Organization
ISROVISION	ISRO Digital Image and Analysis System
ISTRAC	ISRO Telemetry, Tracking, and Ground
IUP	IRS Utilization Project
JEP	Joint Experiment Program
LISS	Linear Imaging Self-Scanning Sensors
NDC	NRSA National Data Center
NRSA	National Remote Sensing Agency, Balanagar, Hydrabad
NNRMS	National Natural Resource Management System
PRL	Physical Research Laboratory
RRSSC	Regional Remote Sensing Services Center
SAC	SRO Space Applications Center, Ahmedabad
SCC	Spacecraft Control Center

TTC	ISRO Telemetry, Tracking and Command
TTG	ISRO Technology Transfer Group
VOSTOK	Soviet launcher
VSSC	ISRO Vikram Sarabhai Space Center, Trivandrum

TTC	ISRO Telemetry, Tracking and Command
TTG	ISRO Technology Transfer Group
VOSTOK	Soviet launcher
VSSC	ISRO Vikram Sarabhai Space Center, Trivandrum

COUNTRY GLOSSARY: JAPAN

ADEOS	Advanced Earth Observation Satellite
ASCA	Association for Science and Cooperation in Asia
AIST	MITI's Agency for Industrial Science and Technology
CEOS	Committee on Earth Observations Satellites
COPUOS	UN Committee on Peaceful Use of Outer Space
EDRTS	Experimental Data Relay and Tracking Satellite
EL	MITI Electrotechnical Laboratory
EOC	NASDA Earth Observation Center, Hatoyama
ERSDAC	Earth Resources Satellite Data Analysis Center
ERSDC	Earth Remote Sensing Data Center
ESCAP	UN Economic and Social Committee for Asia and Pacific
GSJ	Geological Survey of Japan
ISAS	Institute of Space & Astronautical Science
ITIR	Imaging Thermal Infrared Radiometer
JAROS	Japan Association of Resource Observation Satellite
JAPEX	Japan Petroleum Exploration Co.
JERS	Japanese Earth Resources Satellite
JGI	Japex Geophysical Institute
JICA	Japan International Cooperation Agency
JMT	Ministry of Transport
JMA	Japan Meterological Association
JNOC	Japan National Oil Company
J-POP	Japanese Polar-Orbiting Platform
Keidanren	Japanese Business Union
LOS	Land Observations Satellite
LGSOWG	Landsat Ground Station Operations Working Group

MAFF	Ministry of Agriculture, Forestry, Fishing
MEL	Mechanical Engineering Laboratory
MELCO	Mitsubishi Electronic Corporation
MITI/SID	Ministry of International Trade and Industry/Space Industry Division
/MIIB	Heavy Industry Division
MMAJ	Metal Mining Agency of Japan
MOE	Ministry of Education
MOPT	Ministry of Post and Telecommunications
MOS	Marine Observation Satellite
MOT	Ministry of Transportation
NAL	National Aerospace Laboratory
NASDA	National Astronautics and Space Development Agency
NASDA TNSC	NASDA Tanagashima Space Center
NASDA TSUKUBA	NASDA Tsukuba Space Center
NRCT	National Research Council, Thailand
NEC	National Electronic Cooperation
NSPC	Committee for the Promotion of Remote Sensing
RRSS	Technology Research Association of Resources Remote Sensing System
RESTEC	Remote Sensing Technology Center
SAC	Space Activities Commission
SDD	Space Development Division, STA
SJAC	Society of Japanese Aerospace Companies
STA	Science and Technology Agency

COUNTRY GLOSSARY: **USSR**

CONTITRADE SERVICES	US subsidiary of Continental Grain Co. for distribution of SOYUZKARTA data
COSMOS	USSR series of satellites
GLAVKOSMOS	Soviet Commercial Space Organization
MCC	Main Computing Center
MDRPC	Main Data Receiving and Processing Center
MIR	Soviet Space Station
PRIRODA	State Scientific Research and Producing Center
RDRPC	Regional Data Receiving and Processing Centers
SADRS	Simplified Autonomous Data Receiving Station
SOYUZKARTA	The All-Union Foreign Trade Association
SPACE COMMERCE CORP.	US marketing firm for Glavkosmos
URCERE	USSR Research Center for Earth Resources Exploration
VOSTOK	Soviet Satellite Launcher

IV. COMMERCIAL APPLICATION OPPORTUNITIES FOR EMERGING EARTH OBSERVATIONS TECHNOLOGY, 1990-2000

An Analysis

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SYSTEMS APPLICATION OPPORTUNITIES

EPOP NPOP JPOP	SPOT	JERS	MOMS	CBERS	RADARSAT	ERS	SOYUZ-KARTA	ADEOS	MOS	IRS	TOPEX/POSEIDON	
												EMERGING
3	3	3	1	3	1	1	2	3	3	3	0	COMMERCIAL AGRICULTURE
3	1	2	1	1	3	3	0	2	1	1	3	OCEAN ENGINEERING
1	2	0	3	0	0	0	3	0	0	0	0	MEDIA/LEGAL
3	2	3	2	2	2	2	1	1	1	1	0	ENVIRONMENT
												ESTABLISHED
3	1	2	1	1	3	3	0	1	3	0	2	COMMERCIAL FISHING
2	3	3	3	3	2	2	3	2	1	2	0	ENGINEERING, CONSTRUCTION MAPPING
2	2	3	3	3	3	3	2	2	2	2	2	ENERGY AND MINERALS
2	3	3	3	3	2	2	2	3	2	2	0	LAND USE MANAGEMENT
2	3	3	3	3	2	2	3	1	1	1	3	DOD/INTELLIGENCE
22	20	22	20	19	18	18	16	15	14	12	10	TOTALS

(MOMS, FREE FLYING)

ASSESSMENT OF APPLICATIONS POTENTIAL OF EMERGING EARTH OBSERVATIONS SYSTEMS

A detailed assessment of commercial earth observations applications opportunities was not completed as part of the present study for several reasons. An inordinate amount of time was expended assembling up-to-date information about the respective national programs. This information is assembled as Sections I., II., and III. It is believed that the assessment of the commercial viability for these programs is valid as presented at the present time. In addition, extensive evaluations of earth observations applications opportunities were presented in the three recently distributed (1988/89) contractor reports by KRS, TASC, and the Egan Group commissioned by NOAA in their review of an "Advanced Civil Earth Remote Sensing System" ("ACRESS") for the National Space Council. Finally, any study of earth observations applications commercial opportunities for the 1990's must take into account the new "Rules of the Road" discussed in the summary, Section V.

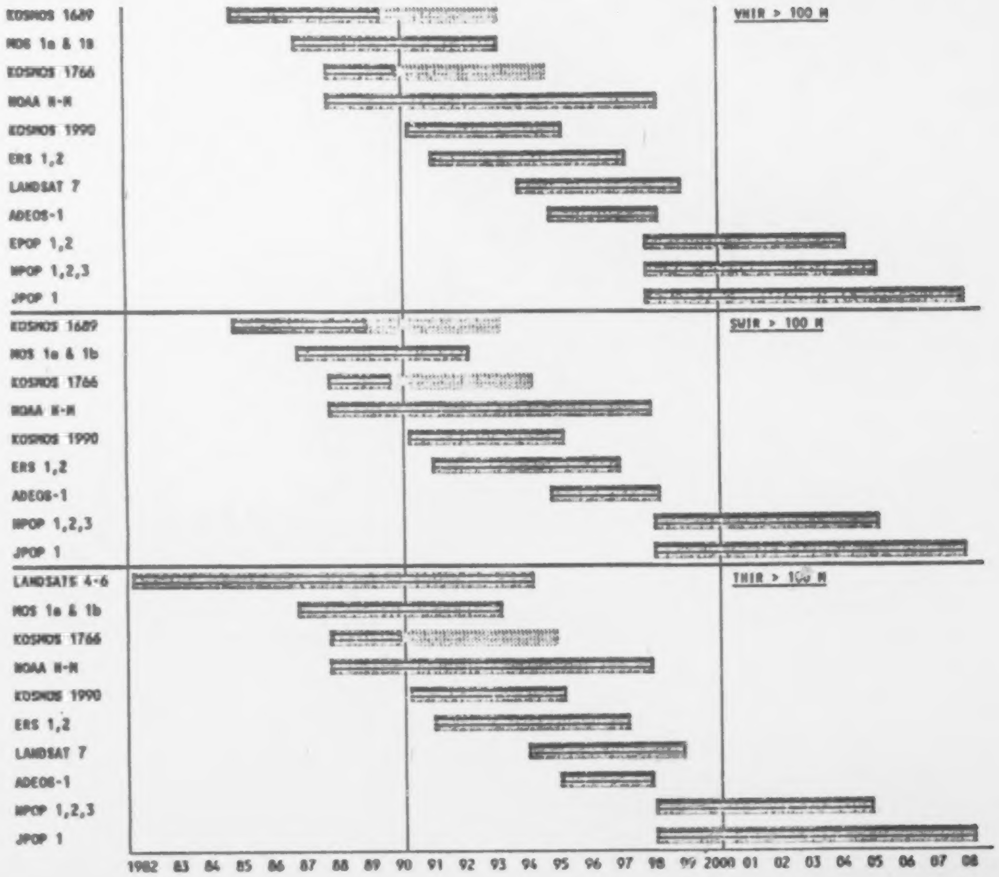
A simple assessment of emerging and established earth observations applications opportunities for the national system reviewed in this study are shown in the following chart. In this chart systems were ranked low to high (0-3) in their utility for the emerging and established applications fields listed. For the systems studied, the following order for utility for applications opportunities are:

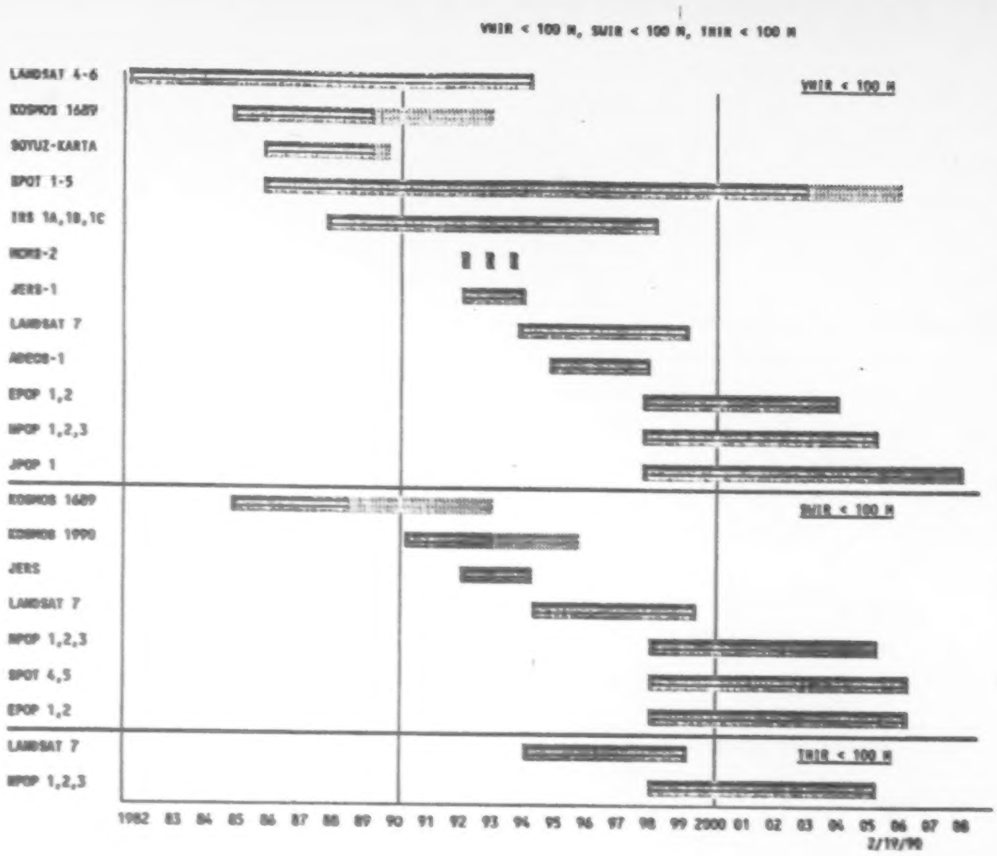
Polar Orbiting Platform Systems > JERS > SPOT

MOMS (free flying) > CBERS > RADARSAT > ERS >

SOYUZKARTA > ADEOS > MOS > IRS > TOPEX/POSEIDON

VNIR > 100 M, SWIR > 100 M, THIR > 100 M




VNIR < 100 M, SWIR < 100 M, THIR < 100 M
VNIR < 100 M
LANDSAT 4-6
KOSMOS 1689
SOYUZ-KARTA
SPOT 1-5
IRS 1A,1B,1C
MOMS-2
JERS-1
LANDSAT 7
ADEOS-1
EPOP 1,2
NPOP 1,2,3
JPOP 1
SWIR < 100 M
KOSMOS 1689
KOSMOS 1990
JERS
LANDSAT 7
NPOP 1,2,3
SPOT 4,5
EPOP 1,2
THIR < 100 M
LANDSAT 7
NPOP 1,2,3
1982
83
84
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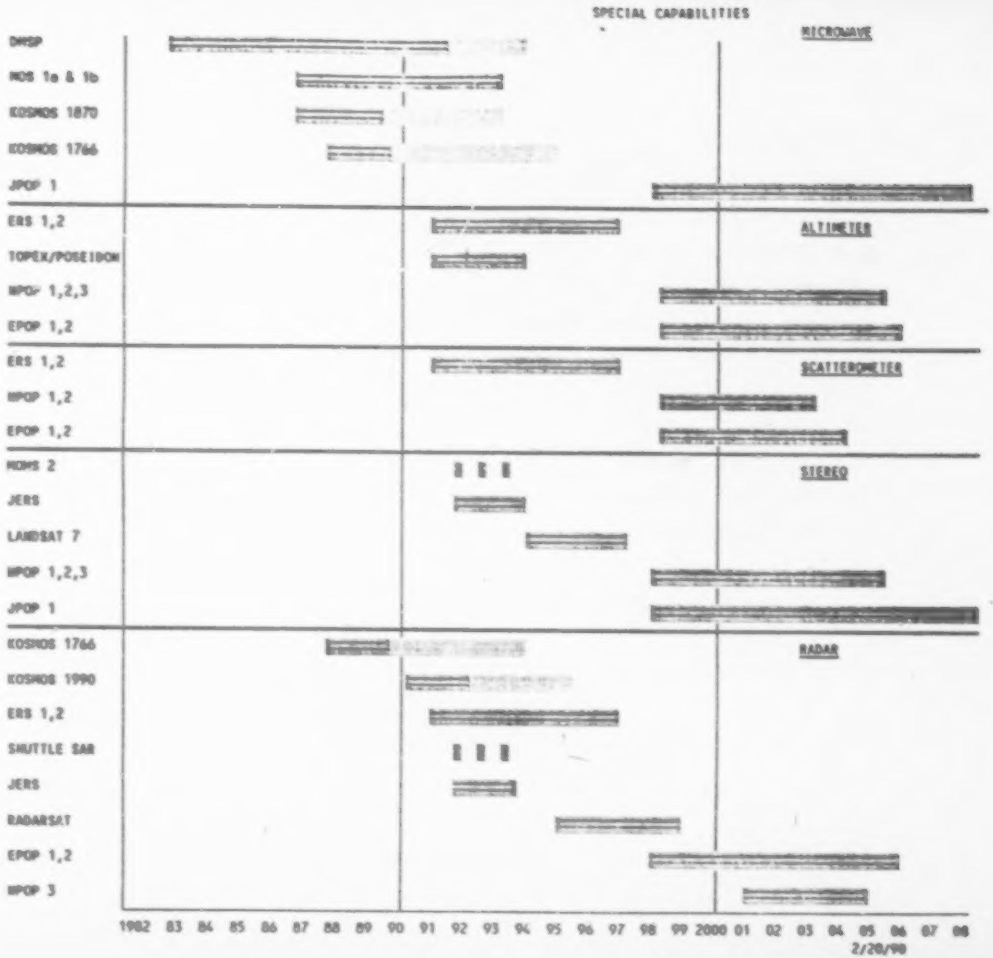
SPECIAL CAPABILITIES

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POTENTIAL BARRIERS TO COMMERCIAL DEVELOPMENT OPPORTUNITIES, FOREIGN AND DOMESTIC

In the previous section, which describes the international development programs for commercial earth observations, the programs are compared in the chart on page IV-8 in terms of relative commercial viability. This chart was developed on the basis of seven commerciality parameters, the commerciality of which are, in an indirect manner, inversely related to potential barriers to commercialization. These parameters include government funding, private sector funding, policy links between government and the private sector, technology links between space systems and users, technology transfer links between basic and applied earth observations research and commercial development, utility of data, and on-going continuity of programs.

GOVERNMENT FUNDING

Government funding for the eight national earth observations programs under discussion represents the parameter with the least barriers to commercialization in that, to date, all programs have been developed with government funding. It is the transfer of government funded programs to the private sector that has not been successful to date. The French SPOT program appears to be the furthest along in being transferred to the private sector; but even the SPOT program requires continued government funding of the space segment at least through SPOT 4 to the year 2003. The ongoing difficulties in the privitization of the Landsat program point to its continued need of government subsidy. In all of the programs planned through the 1990's, continued government funding of at least the space segment appears to be a required predisposition to ultimately commercializing earth observations systems. Furthermore, government funding seems to be necessary to develop new earth observation technologies such as the new sensors and on-board processing capabilities which will be coming on-stream during the 1990's.

While government funding of at least the space systems seems to be a requirement for the 1990's and is planned for the systems discussed, ultimate commercialization of these systems in their entirety will require yet to be developed mechanisms for a transfer of the programs to the private sector with a concomitant withdrawal of direct government support and funding. Alternatively, successful commercialization of future earth observations systems may ultimately be defined as a working partnership between government support and the commercial private sector.

PRIVATE SECTOR FUNDING

An alternative point of view to the above is that continued government funding of national satellite programs is a major barrier to truly entrepreneurial commercial development of earth observations space and ground segment systems because of unfair government subsidization. However, it is also true that, to date, no truly commercial system has been seriously proposed by the private sector that is as complex and expensive as the systems under discussion. This suggests that it is difficult to raise the $150-300 million dollars needed for state-of-the-art earth observations space systems that can be amortized over 3-5 years at a commercial profit.

Private sector funding of ground segment systems (data processing, archiving, and distribution) is presently virtually non-existent. In the French Spot program, the ground segment operator, Spot Image Corporation, was initially funded by government, and is still 61% government-owned. Funding for continued operations of the ground segment are now mostly generated through commercial sales of Spot data. In the U.S., some funding for operational ground segment costs are generated by sales of Landsat data, but funding of a future improved ground segment system to handle Landsat 6 data is still expected to come largely from government. Private sector funding of ground segment systems is not presently planned for any of the other programs, except perhaps the commercial portion of the Canadian RADARSAT program. Radarsat International (RSI) will operate a private sector commercial ground segment system for part of the RADARSAT data, but it isn't known at present how much will be private sector funded and how much by the Canadian government.

A major barrier to the commercial development of international earth observations has been the slow development of a value-added industry and a viable end user market. One major reason for this situation has been the lack of significant investment in market development by the data producers and the embryonic value-added companies. One factor in this situation is that for both Landsat and Spot, early major industrial users were the energy and mineral companies who could afford early expensive processing technologies as underwritten by public funds. To sort out these various purposes to be served by the national earth observations programs requires the closest possible cooperation and linkages for policy development and implementation between the government and private sector interests. This is especially so if the national goal is to commercialize the earth observations programs. These linkages provide the optimum means for the satisfaction of both government and private sector user needs, user feedback, and development of effective data management systems.

DATA LINKAGES BETWEEN SPACE SYSTEMS AND USERS

Commercialization potential for earth observation systems is enhanced for those systems where data from space systems is developed, processed, and distributed according to user needs. The data linkages between the space systems, the ground systems and the users are critical to the commercialization of earth observations systems. Barriers to such linkages include improperly designed data management systems and product development so that the user's needs are not adequately met. The French, Japanese, and Canadian systems have been well designed to enhance the data linkages between the space systems and both the government and private sector user communities. Data flow or linkages between space systems and the end users are less well developed in the BESA, Brazilian-PRC, Indian, German, and Soviet Programs, thus creating partial barriers to their commercialization at present.

BASIC SCIENCE LINKAGES TO COMMERCIAL DEVELOPMENT

In the earth observation programs covered in this report, the systems were developed from technologies based on basic and applied science programs funded largely by governments. Early R&D investment in earth observations in the United States has formed the basis for much of the technology development in other countries' earth observations systems. The measure of how well these government R&D programs have been linked through technology transfer and applications demonstrations and development programs to the user community is directly related to their commercial potential. In the French and Japanese programs, basic and applied R&D is jointly funded by both the government and private sector user organizations and is directly linked through cooperative applications demonstration, development, education, and training programs to the government and private sector user communities. In the French program, this linkage supports the commercial sale of SPOT data. The Japanese program has not yet been commercialized, but the basic science to applied user linkage in the Japanese program will minimize this barrier upon its commercialization. In other countries, the linkage between basic science research programs and applied applications development for commercial development is less well developed and thus serves as at least a partial barrier to commercialization at the present time. This barrier is most pronounced in the United States where cooperative basic earth observations research with the potential commercial private sector community is de facto discouraged rather than strongly encouraged by NASA basic research policies.

UTILITY OF DATA

The overall utility of data in meeting the end user data requirements is a strong factor in its ultimate commerciality. In earth observations systems such as the Landsat MSS and the NASA Earth Observing System (EOS) polar orbiting platform program, the sensor systems and the data products were initially designed for research purposes or technology development and not to meet operating end user requirements. In a similar sense, the ESA ERS-1 and the German MOMS were initially designed for research and technology development. In these cases, the commercial user community needs were not of primary design importance. For example, issues such as global coverage, data recovery by tape recorders, ground stations, and TDRSS, rapid data turn around times, and common data formats were not major design criteria.

For these reasons, the utility of the data from these systems is relatively low and serves as a partial barrier to their commercialization. On the other hand, the French Spot, Japanese JERS, Canadian RADARSAT, and Indian IRS systems were each designed to meet certain national user data requirements. As such, the utility of these systems in meeting user needs will be higher and the utility barrier to commercial development will be minimal.

DATA CONTINUITY

A major barrier to commercial development of earth observation systems has been the lack of certainty in government commitment to earth observations programs. This barrier has been a major reason for the slow development of the value-added industry in support of the United States Landsat Program. Lack of a clear government policy as to the continuity of the space segment of the Landsat Program significantly discouraged users from investing in the expensive early development or uses of Landsat data. This relates to data purchases, purchases of data processing equipment, and user commitment to investing in Landsat data as a critical information source for business decisions without assurance of continuity of such data sources. In other countries where government still must subsidize the space segment systems, the lack of commitment to data continuity also serves as a potential barrier to commercial development by the user community. Among the national programs covered in this study, the French Spot programs stands out above all the others with respect to commitment to data continuity. Recognizing the need for continued government subsidy funding of the SPOT satellite segment, the French government has assured its ground segment commercial developer, the Spot Image Corporation, that it will fund the Spot satellite program at least through SPOT 4 to the year 2003. This commitment to satellite continuity provides for commercial user assurance needed to encourage investment in the Spot system for continued uses of information developed from Spot data. Commitment to the continuity of the Spot program strongly enhances its commerciality for the period 1990-2000.

VIABILITY OF INTERNATIONAL GOVERNMENT EFFORTS TO COMMERCIALIZE NATIONAL EARTH OBSERVATIONS PROGRAMS

In the previous section, the basis for comparing the national programs for commercial earth observations was described in terms of factor indirectly related inversely to barriers to commercialization. These factors are combined and used to rank the various programs as to the viability of the government efforts to commercialize their national earth observations programs. This viability ranking is shown in the accompanying chart (page IV-8). The viability of the various government commercialization efforts is ranked and analyzed in summary from below as to decreasing viability of the government commercialization efforts for each national program. In decreasing order of commercial viability, they are France, Japan, Canada, ESA, Brazil-PRC, India, the Federal Republic of Germany, and the USSR.

VIABILITY OF NATIONAL PROGRAMS FOR COMMERCIAL EARTH OBSERVATIONS

COUNTRY	70 MAX	GOV'T FUNDING	PRIVATE SECTOR(PS) FUNDING	GOV'T-PS POLICY LINKS	SPACE TO USER LINKS	BASIC APPLIED SCIENCE COMM'L LINKS	UTILITY OF DATA	CONTINUITY
HIGH								
FRENCH SPOT	65	10	8	10	9	9	9	10
JAPAN JERS	60	10	7	10	7	10	9	7
MODERATE								
CANADA RADARSAT	54	10	5	10	8	8	8	5
ESA ERS	48	8	5	7	5	8	8	7
BRAZIL-PRC CBRS	47	8	3	9	7	8	7	5
LOW								
INDIA IRS	45	10	2	7	6	7	7	7
FRG MOMS	43	8	5	10	5	7	5	3
SOYUZKARTA GLAVKOSMOS	41	10	2	8	5	7	6	6

HIGHLY VIABLE COMMERCIALIZATION PROGRAMS

FRANCE

The French national Spot earth observations program is well on its way towards commercial maturity. It is characterized by strong government-industry linkages for policy development and implementation as well as cooperative basic and applied research and joint technology transfer programs. In addition, the Spot program was well designed to meet government and industry end user requirements. The data flow from the space satellite system through the ground segment is well designed to provide data in the product format of greatest utility to the end user. The Spot data itself was carefully selected for optimum utility for specific user requirements and to supplement user needs not provided by its Landsat competitor. Finally, the strength of the commercial potential of the French Spot program lies in the government's assurance of continuity of the satellite data stream until such time as an orderly market development for Spot data can take place over a 10-15 year period (1986-2003).

JAPAN

The Japanese government has yet to decide whether it will commercialize it's Japanese Earth Resources Satellite - 1 (JERS-1) program. If such a decision is made, it is well positioned for commercial development. The program is clearly the product of close cooperation between government and private sector end users. The sensor system and data formats were designed specifically for high utility in meeting energy, mineral, and other end user requirements. Moreover, there has been very close government-private sector coordination on policy development and implementation as well as in joint basic and applied research and applications development, education, and training programs. In fact, the main strength of the JERS-1 program has been its development through a strong government-industry partnership from its inception. While no JERS-1 global marketing program, such as that of France's Spot Image Corporation, exists at present, the strong Japanese government-industry partnership should provide for rapid commercialization of the technically well positioned JERS-1 program once a decision is reached.

MODERATELY VIABLE COMMERCIALIZATION PROGRAMS

CANADA

The Canadian RADARSAT earth observations program ranks as the highest of the moderately viable commercialization programs. As with the French and Japanese programs, the RADARSAT program is the product of close government-private sector cooperation. It is in fact a mixed experimental government and private sector commercial program. RADARSAT data and data formats were designed specifically to meet certain government and private sector end user needs, particularly for ocean and ice information requirements. In this specific area, the data will be of high utility, while supplementing user requirements for other land applications. The RADARSAT program benefits from extensive and close government-private sector cooperation in supporting basic research and applications demonstrations, education, and training programs. A potential difficulty in the commercialization of the RADARSAT data will be the dual nature of the government utilization and distribution of data for government uses along with the commercial distribution of data by the vendor, Radarsat International (RSI), to the global commercial market place.

EUROPEAN SPACE AGENCY (ESA)

The ESA Earth Resources Satellite - 1 (ERS-1) program was originally developed by the 14 member government space agencies of the European Space Agency as a research and experimental system without commitment to commercial development. Recent policy recommendations to the ESA Council by the ESA Assembly in December 1989 for commercial distribution of limited portions of the ERS-1 data should be ratified by the Council in the spring of 1990. Such commercialization of limited amounts of ERS-1 data will lead to the same dual government use and private sector commercialization dilemma that confronts the Canadian RADARSAT program. Moreover, in comparison, the ESA program is not as well based on cooperative government-private sector development as the previous programs described above. ERS-1 data will have similar utility for both ocean/ice and land applications for C-band SAR radar as with the RADARSAT program. However, the ERS-1 radar sensor characteristics and data formats are not as end user oriented as are those of the RADARSAT program. ERS-1 will provide additional oceanographic altimeter and wind scatterometer data. While the ESA and Canadian programs are similar and the intergovernmental distribution plans for government use of ERS-1 data are well in hand, plans for global commercial distribution and market development for the commercial portion of ERS-1 data remain to be developed.

BRAZIL - PEOPLES REPUBLIC OF CHINA

The China-Brazil Earth Resources Satellites CBERS-1 and -2 are being jointly developed by the governments of Brazil and the Peoples Republic of China along the lines of the Landsat Thematic Mapper and Spot programs. As such, the CBERS data should have moderately high utility and benefit for the existence of a well established end user market. However, no decision has yet been announced by Brazil or the PRC regarding plans for commercial distribution of CBERS data. The CBERS program is considered to be moderate to lower commercial viability because of the utility of the data to an established global earth observations market assuming that the Brazil-PRC partnership decides to commercialize the program and establish, or join an established global marketing organization.

LOWER VIABILITY COMMERCIALIZATION PROGRAMS

INDIA

The Indian IRS program is considered to be of lower commercial viability, although its data could be developed for global commercial development should the Indian government so decide. The IRS data is designed to be highly useful in providing operational information for the Indian agricultural, hydrological and related programs for which it was intended. In other applications, the IRS can be used as intermediate resolution Landsat MSS type data at present and will be technically upgraded during the mid to late 1990s. While provisions are available whereby other countries can arrange to receive the IRS data, there are no known plans for IRS data to be made commercially available anywhere by the Indian government or private sector at the present time.

FEDERAL REPUBLIC OF GERMANY

The MOMS program of the Federal Republic of Germany (FRG) is presently one of earth observations technology development to be flown experimentally on the U.S. Shuttle and perhaps on later space station platforms. The high resolution, stereo electroptical MOMS data itself, has high commercial potential for some specific applications, especially automatic cartography. However, for the MOMS program to have moderate or high viability as a commercial earth observations program, the FRG will have to develop a polar-orbiting or operational space station program for commercial market development.

SOVIET UNION

The earth observations programs of the Soviet Union are the hardest to assess for commercial potential for the period 1990-2000. At present, their programs are low viability. While some Soyuz-Karta film and digitized film products are now available commercially, little is know of how much or what kind of other earth observations data exists or could be made available for commercial interest to the global user community. Clearly, the Soviet Union appears to have the technical potential for commercial earth observations data development, but it is based on current systems designed primarily to provide the Soviet Union with national and international military and economic intelligence. Before the Soviets can seriously develop the commercial potential of their earth observations programs, they must first politically decide to do so. Then, they must set up or negotiate with a major sophisticated commercial western style company to develop, command, and hold onto any significant part of the growing competitive, global earth observations markets. While it is premature to accurately project the commercial viability of Soviet earth observations programs and technologies, the current historic changes developing in eastern Europe and in the Soviet Union suggest that anything is possible in the next ten years!

V. SUMMARY: NEW RULES FOR COMMERCIAL EARTH OBSERVATIONS FOR 1990-2000

	COMMERCIAL APPLICATIONS	COMMERCIAL PROGRAM VIABILITY
HIGH	Japan JERS	France SPOT
	France SPOT	Japan JERS
MIDDLE	FGR MOMS**	Canada RADARSAT
	Canada RADARSAT	Brazil-PRC CBERS
	Brazil-PRC CBERS	ESA ERS
	ESA ERS	
LOW	USSR SOYUZKARTA	India IRS
	Japan ADEOS	FRG MOMS
	India IRS	USSR SOYUZKARTA
	US/France TOPEX/POSEIDON	

** FRG MOMS ranked high for applications as an operation platform system, not for shuttle flights only.

STUDY SUMMARY

In the short year since this study was first discussed, several new trends have emerged which will significantly impact the commercial development of earth observations programs throughout the world. This study set out to examine the commercial objectives, capabilities and opportunities of earth observations programs outside the United States. It set about in a standard manner to:

1. Profile the non-U.S. earth observation systems and programs;
2. Evaluate the commercialization programs for space craft and sensors as well as for the ground receiving and data distribution systems;
3. Analyze the international programs for market development of earth observations; and
4. Analyze the commercial application opportunities of emerging earth observations technology for the period 1990-2000.

The majority of the time spent in this study was devoted to the first three tasks. In conducting this study, a standard approach was taken in assessing the satellite systems and the potential applications which might lead to commercial development. Little new information was added to the recent applications studies conducted by three NOAA contractors and EOSAT. The three contractors conducted extensive applications appraisals during their 1987-88 studies assessing the viability of an "Advanced Civil Earth Remote Sensing System" (ACERSS) to succeed Landsat 6. However, in reviewing the commercial opportunities for international earth observations programs in this study, three major trends are identified which will significantly impact commercial earth observations during the period 1990-2000, and which might markedly change the standard way of evaluating applications opportunities and earth observations commercialization in general from most previous studies and conclusions.

For the most part, the commercial viability for commercial earth observations closely follows the applications opportunities, especially in the case of the higher ranked programs.

These three major new trends effecting earth observations commercializations in 1990-2000 are:

1. The rapid growth of inexpensive PC-based computer information extraction for the end user from integrated remote sensing data through Geographic Information Systems (GIS);

2. The extensive growth of the use of earth observations data for major government and private sector environmental study, monitoring, and management; and

3. The "Berlin Wall Effect" or the international "unmilitarization" between east and west and its impact on the relations and limitations on military and civilian earth observations worldwide policies.

GROWTH OF PC/GIS INFORMATION EXTRACTION FROM EARTH OBSERVATION DATA

Since the U.S. Department of Commerce's Source Evaluation Board evaluation of the privitization and commercialization of the Landsat program in 1982-84, most students of earth observations commercialization have assumed that the growth of the value-added industries would rapidly provide sufficient cash flow to commercialize the entire systems. So far, this has not happened for a variety of reasons. Chief among these reasons has been:

1. Lack of private sector investment in value-added market development;

2. Time required for user development of information extraction from GIS system from earth observation data; and

3. Growth time required for industry development of less expensive PC/GIS systems with respect to more expensive mini- and maxi-frame data processing systems of the 1970's and 1980,s.

During most of the 1970's and 1980's, the sophisticated use of earth observations information data was limited greatly to large resource companies and government agencies who could afford the expensive main and mini-frame data processing systems needed for earth observations data processing. During the 1980's, users began to master new GIS systems and the use of earth observations was changed by the trend of integrating earth observations data with other data bases. As indicated in the following two charts from TERRAMAR Resource Information Services, Inc., in the past few years, there has been a major development of less expensive PC based GIS and data processing systems which will have significant impact on the growth of the use of earth observations data through the 1990's.

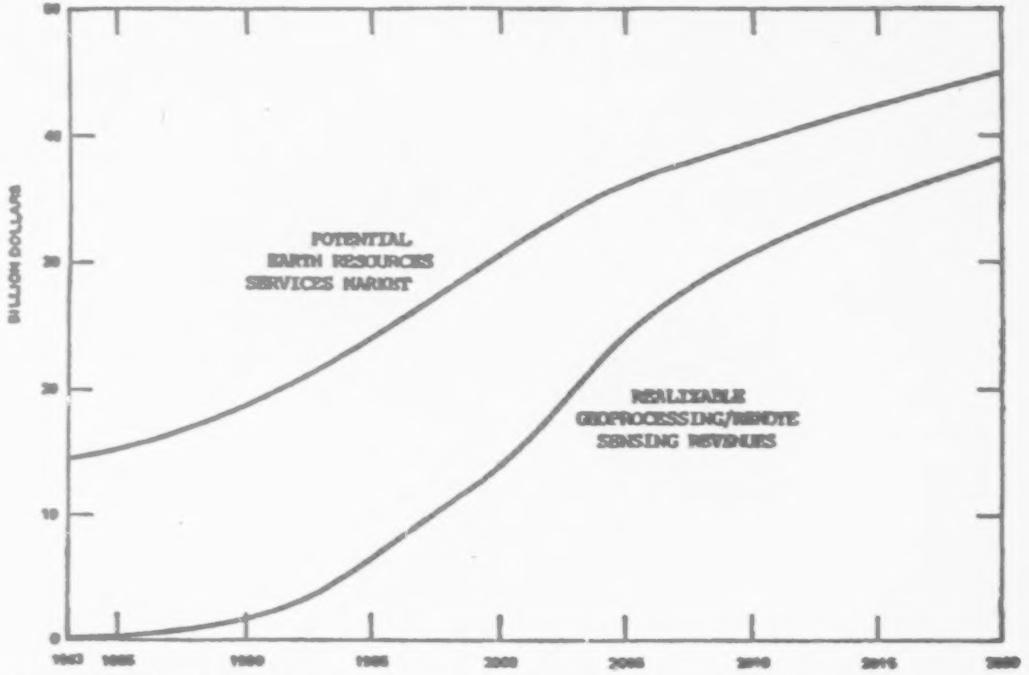
Two growth trends of PC/GIS information extraction for earth observations data which will impact commercial assessment of the period 1990-2000 are:

1. In evaluating the commercial applications potential of new emerging earth observations systems, it will be necessary to assess not only a matrix approach to applications and sensor systems, but also the market potential of the various end users for information quanta that can be extracted from each sensor measurement in each applications area. For example, if a certain radar measurement can quantify how much timber is in an acre, how many different quanta or types of useful information can be extracted commercially from that measurement?

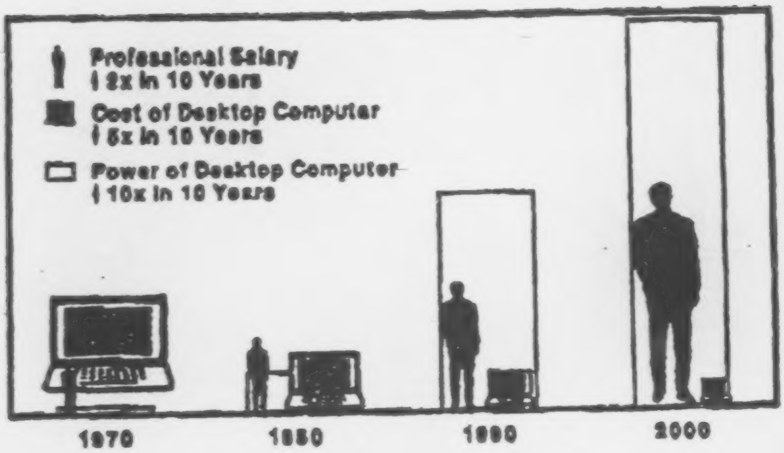
2. In evaluating whether future earth observations programs can be commercially viable for both the space and ground segments, it will be necessary to assess whether the cash flow from the growing commercial information extraction described above will catch up and surpass the growing cost of advanced earth observation systems. That is:

$$\text{For commercial systems viability: } \frac{\text{Information Cash Flow Growth}}{\text{E.O. System Cost Growth}} >> 1.0$$

PROJECTED REMOTE SENSING MARKET-POTENTIAL AND REALIZABLE REVENUES

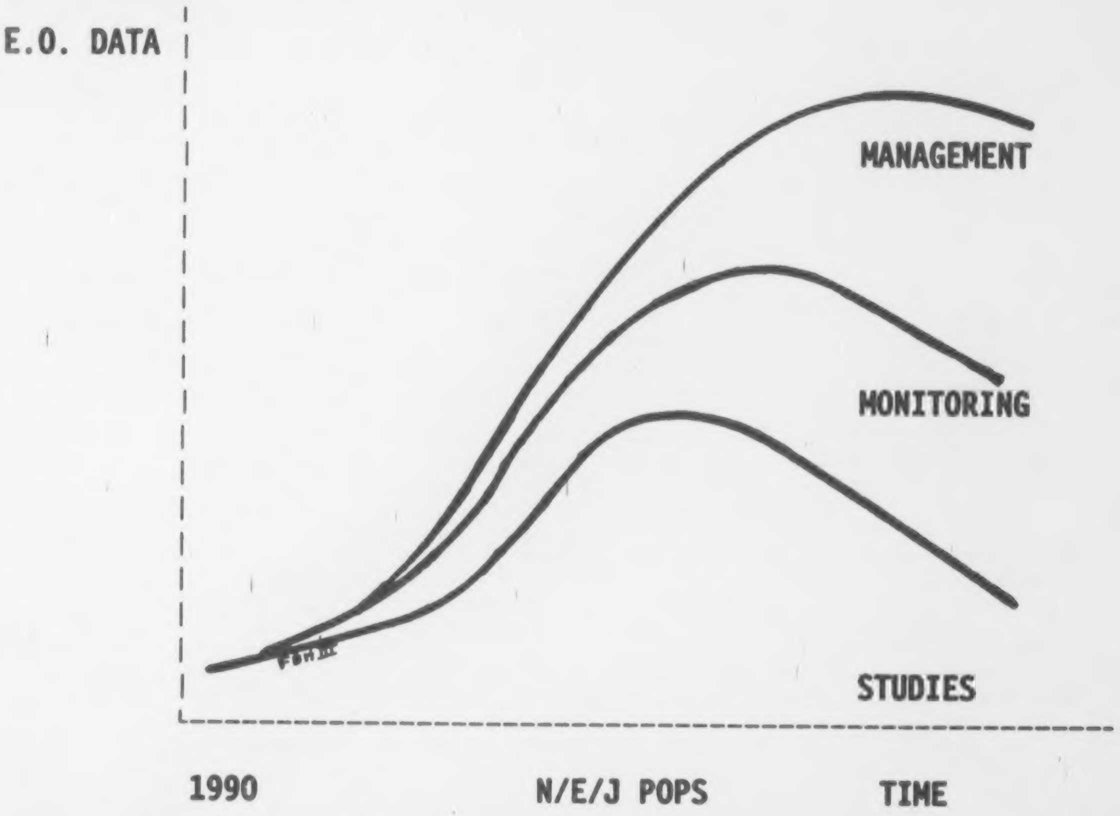


Source: [illegible] estimates



Source: Gartner Group, Inc.
Courtesy: Terra-Mar

SHOWN GRAPHICALLY:



EARTH OBSERVATIONS AND ENVIRONMENTAL APPLICATIONS

Until 1989, most applications of present and future earth observations systems have been in more or less common fields of agriculture, forestry, hydrology, energy and minerals exploration, land use management, oceanography, and related fields. The use of earth observations for environmental applications has been largely within these disciplinary areas. However, with the recent thrust of NASA's "Mission to Planet Earth" in support of developing the Earth Observation System (E.O.S.) for NASA's polar-orbiting platform program, the remarkable political fallout of NASA's ozone hole and global warming studies, the development of the interagency Committee on Earth Sciences (CES) Global Change Research Plan, and the related growth of similar, cooperating polar-orbiting-platform and global change programs in other countries, all lead to the conclusion that proposed, earth observation systems will become the fundamental observation technology for rapidly expanding major environmental applications during 1990's.

The growth potential for the use of earth observations for environmental applications will occur in three main areas. They are:

1. Basic and Applied Global Change Studies;
2. Government Policy and Regulatory Monitoring; and
3. Government and Private Sector Environmental Management Applications

A critical factor evaluating the commercial potential of earth observations systems such as the E.O.S. program will be to determine what roles will be played by the following:

1. Non-commercial government use of earth observations data in the "public good" for studies, monitoring, and management;
2. Private sector use of earth observations data for studies, monitoring and management; and
3. The growth potential of private sector value-added information companies to service both government and private sector needs as noted above.

INTERNATIONAL "UNMILITARIZATION", OR THE "BERLIN WALL EFFECT"

Throughout the development of earth observations programs in the U.S., USSR, and elsewhere, civilian earth observations programs such as Landsat have been historically subject to the National Security interests, limitations, and budgetary competition. While it is impossible in this study to assess the incredible and amazing historical geopolitical changes currently taking place in Europe, the Soviet Union, and the Peoples Republic of China, it seems abundantly clear that the relative roles of military and civilian earth observations will undergo major perturbations during the 1990's. In many respects, there will undoubtedly be major changes in the "Rules of the Road" and thus in anyone's current assessment of the commercial applications opportunities or commercial systems viabilities for planned programs worldwide.

Discussions with some parties knowledgeable with national security interests in earth observations suggest, that in spite of the "Berlin Wall Effect" (that is the presumption of the lessening of, or "unmilitarization", rather than demilitarization, of "east-west" tensions and adverse policies), the current uncertainties of what geopolitical changes will take place will cause national security information gathering to increase rather than decrease in the near future, at least until geopolitical events stabilize. This won't occur until the increase of national security intelligence concerns is surpassed by the stabile relaxation of "east-west" geopolitics, such as:

East-West Geopolitical Relaxation

E.O. "unmilitarization" when: ——————————————— >> 1.0.

National Security Concerns

From an optimistic view point, once east-west geopolitical stabilization is reached, then there maybe a "unmilitarization" of restrictions and limitations of the development of new international earth observations systems with a current growth in new commercial opportunities. An example might be the significant lessening of major power resistance to timely, high spatial resolution systems.

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546

Reply to Attn of: L:MDD:L90-2078f

OCT 19 1990

Honorable Bill Nelson
Chairman
Subcommittee on Space Science
and Applications
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Enclosed are the responses to written questions submitted jointly with Chrm. Ralph Hall resulting from the July 24, 1990, hearing at which Dr. Tilford testified concerning international cooperation in Earth Observing System (EOS) activities.

This material completes the information requested during that hearing.

Sincerely,

Mary D. Kerwin

Mary D. Kerwin
Director, Congressional Liaison Division

Enclosure

cc:
Honorable Ralph M. Hall

Responses to written questions submitted by Chrm. Nelson and Chrm. Hall resulting from the July 24, 1990, hearing.

QUESTION 1:

In a meeting on May 4, 1990 with representatives from NOAA, EOSAT, and Congress, NASA officials indicated they would request that the National Research Council (NRC) conduct a study of the accessibility and cost of Landsat data for research purposes. Yet in the hearing on July 24, 1990, Dr. James Baker from the NRC indicated that it had not received a formal request for such a study, although he believed such a request was forthcoming.

a) Why has NASA not submitted a request for the NRC to conduct the study? Does NASA intend to do so?

ANSWER 1:

Following the July 24 hearing, Dr. Tilford did contact the respective chairmen of the NRC committees reviewing the U.S. Global Change Research Program (USGCRP) and the Earth Observing System (EOS). Neither of the committees considered the Landsat data issue to be a specific part of their charter or one which they could reasonably be expected to handle given the deadlines for submitting their reports on the USGCRP and EOS. Both committees indicated they would be willing to examine the issue at a later time.

In the meantime, the Chairman of the FCCSET Committee on Earth and Environmental Sciences (CEES) and representatives of the National Academy of Sciences (NAS) have discussed the possibility of a study. Based on their discussions, the CEES is now preparing a final request to the NAS for the conduct of such a study.

There have been extensive discussions within the Administration concerning the future of the Landsat program. A major concern has been the importance of the Landsat data for scientific purposes in the U.S. Global Change Research Program and the relatively limited use of that data by Federal and university researchers because of its high cost. The recently released NRC review of the USGCRP and the EOS program made special note of this problem, saying that "in our view, Landsat data are sufficiently important to global change research that means should be found to include them in EOSDIS [the EOS Data and Information System], whether by revising the Land Remote Sensing Commercialization Act, if necessary, or by paying (again) for the data." NASA agrees with the NRC assessment of the importance of Landsat data as part of the global change data set for long term trend analysis.

The NRC has indicated that they would not be able to reply to a request with an urgent turnaround time, such as that for the USGCRP and EOS reviews. NRC officials have estimated that a full scale review/assessment of Landsat data archives and their relative importance to global change research could take up to a year to complete.

QUESTION 2:

Who does NASA consider to be the "end users" of EOS data?

ANSWER 2:

NASA considers the global change research community (university, government, and industry) worldwide to be the primary end users of EOS data. This community encompasses the researchers whose work focuses on some element of Earth science research or on the interdisciplinary links between these elements. In a larger sense, NASA anticipates that a far broader community will also be interested in using data from the EOS Data and Information System (EOSDIS). This broader community includes policymakers and the general public, as well as those interested in applications of the data for other scientific, public, environmental, or commercial purposes. Included in the planning for the EOSDIS is the Consortium for International Earth Science Information Networks (CIESIN) in Michigan which will make the data within the EOSDIS more accessible to applied users and policymakers. This will provide to non-research users -- ranging from government decision-makers to environmentalists to farmers and foresters -- an understanding of EOS and an ability to effectively tap into EOS data. CIESIN's role might include the production of special products and selected standard products and the archival and distribution of these products for use by non-researchers. CIESIN is expected to serve the EOS research community as a link to databases derived for policy formulation and other applied activities.

a) Are all of these user groups represented in discussions among space agencies about common international data standards and access policies?

ANSWER 2a:

Science interests have been well represented on the panels and groups that formulated the design and strategy for the EOSDIS and on advisory bodies that have subsequently reviewed and commented on NASA's approach. The Announcement of Opportunity for the EOSDIS solicited input from the entire user community. The international Committee on Earth Observations Satellites (CEOS) Working Group on Data has been active in defining common data formats for user products to facilitate the use of similar data from different satellites, while the Earth Observation International Coordination Working Group (EO-ICWG) has pursued common data policies among the international partners in the polar platform program. The national members of both of these groups have made strong efforts to collect input from their various user communities and to reflect varying data needs within the proposed international data policies.

In the U.S., a significant amount of end user input on the design and policies for the EOSDIS have been received over the last few years through the EOS Investigator's Science Advisory Panel for EOSDIS. The recently released NRC review of the U.S. Global

Change Research Program and the EOS Program stated that the Panel "has successfully focused the concerns of a broader research community, and has articulated the specific requirements of scientific users in the context of the EOS mission and the USGCRP." The NRC report recommends that the Panel remain a long term source of input; NASA agrees with this assessment. The draft Request for Proposal (RFP) for EOSDIS has just been released for comments from the research community and industry; those comments will be carefully reviewed before the final RFP release in 1991.

QUESTION 2b:

Concern was expressed in the July 24 hearing over NASA's receptivity to end user input. How will these concerns be accommodated from this point forward?

ANSWER 2b:

As noted in the previous answer, both the U.S. and international groups have made extensive efforts to keep the applications and other user communities aware of the planning for the EOSDIS and to seek their input and advice. In addition, plans and policies for the EOSDIS have been reviewed extensively by advisory groups of the NRC, NASA, and other scientific and technical organizations (e.g. AIAA) which have members representing a broad cross-section of end user communities. We expect such reviews will continue and potentially expand in the future to continue the vital flow of information between EOSDIS designers and users.

It is worth noting that there are occasional conflicts between users' desires to have access to EOS data and the current laws governing the use of that data. NASA has designed its policies to reflect the provisions of the Land Remote Sensing Commercialization Act and other legislation which specifies what data can be released to commercial and other users and by what process.

QUESTION 2c:

Would NASA be receptive to the formation of an independent "EOS Users Advisory Panel" to identify the needs and concerns of public and private sector researchers?

ANSWER 2c:

We do not believe that such an additional panel is needed or would be useful at this time. NASA believes that past, current, and planned efforts to incorporate user input into the planning for EOSDIS have been quite successful, and that the forums established for such input will continue to serve both the communities and NASA quite well. In addition, the role of CIESIN as an affiliated active archive center for the EOSDIS will offer the applications community and others an additional avenue through which to offer input into ongoing planning for the evolution of the data system.

NATIONAL SPACE DEVELOPMENT
AGENCY OF JAPAN

2-4-1, HAMAMATSU-CHO, MINATO-KU,
TOKYO, JAPAN

The Honorable Bill Nelson
Chairman
Subcomittee on Space Science
and Applications

The Honorable Ralph M. Hall
Chairman
Subcommittee on International
Science Cooperation

ER90-76
Sept. 11, 1990

U.S. House of Representatives
Committee on Science, Space, and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515

Dear The Honorable Nelson and Hall

I have received your letter of July 13, 1990. I would like to express many thanks to you for giving us this opportunity to explain our activities in the field of earth observation. Please find our statement which I enclosed.

The role from space segment is to be very significant and beneficial not only for both countries but all of human kind. I hope that this information attached will be satisfied with your questions and make mutual understanding deepen.

Sincerely yours;

T. Yamagami
Takuji Yamagami
Director
External Relations Department

CC : M.Nagatomo, Director NASDA WDA Office

Statement to
Committee on Science, Space, and Technology
U.S. House of Representatives

Takuji YAMAGAMI
Director, External Relations Dep.
National Space Development Agency of Japan
Aug. 27, 1990

1. General Overview of Japan's Global Change Program

1.1 At the Cabinet Meeting on 12 May 1989, the Japanese Government decided to periodically convene The Council of Ministers for Global Environmental Conservation in order to effectively promote overall measures to resolve environmental problems. The council will be attended by 20 Cabinet Ministers, but these 20 will not include the Minister of Justice and the Minister of the Defense Agency. When convened, the council will deal with problems such as ozone layer depletion, global warming, acid rainfall, transfer of toxic waste beyond international borders, ocean pollution, extinction of wild species, tropical deforestation, desertification, and pollution in developing countries.

1.2 The Council of Ministers resolved to promote comprehensive research and study, observation and monitoring, and technology development to conserve the global environment in close cooperation with pertinent Ministries and Agencies. Some examples of specific activities are

a. Promote research and study
Participate actively in international cooperative research programs.
Promote research and study on phenomena relating to the global environment and on measures to conserve the global environment.

b. Promote observation and monitoring
Promote satellite monitoring.
Strengthen international observation and monitoring networks.

c. Promote technology development
Promote technology development across broad fields to contribute to international efforts to conserve the global environment.

1.3 The Council of Ministers also decided to formulate measures Japan should take to protect our planet from the greenhouse effect. The measures are to be formulated by early fall 1990 and will include

a. Promoting scientific research and study, and observation and monitoring of greenhouse effect mechanisms and forecasting climatic change.
b. Developing technology for carbon-dioxide fixation and utilization of fixed carbon.

1.4 The Council for Science and Technology, an advisory body to the Prime Minister, submitted a report to the Prime Minister in June 1990. Based on this report, the Prime Minister established a fundamental plan for research and development in Earth science and technology spheres. The plan includes basic ideas for promoting research and development in Earth science and technology spheres as well as important research and development subjects.

2. NASDA's Earth Observing Systems

2.1 NASDA has been engaged in developing the technology for Earth observing systems from space. One such system is the Geostationary Meteorological Satellite (GMS) series, which has been used to observe meteorological phenomena in the Asian Pacific Area since 1977. Another operational Earth observing system is Japan's first polar orbiting Earth observation satellite, Marine Observation Satellite-1 (MOS-1). NASDA is now operating both MOS-1 and MOS-1b.

2.2 Earth Resources Satellite-1 (ERS-1) and Advanced Earth Observing Satellite (ADEOS) are now being developed. The launch of ERS-1 is scheduled for early 1992, and ADEOS, for early 1995. NASDA is now studying the next Earth observation satellites: Tropical Rain Measurement Mission (TRMM) and Japan Polar Orbiting Platform (JPOP).

2.2.1 The primary mission objective of ERS-1 is to explore natural resources. The Synthetic Aperture Radar (SAR) will detect the land surface topography with high precision. The Short-Wave Infrared Radiometer (SWIR) will measure the reflectance of the sunlight in several short wave infrared bands. From this data we will identify areas where natural resources might be located. We also expect that using SAR, we will be able to detect the ice concentration and measure the ocean topography.

2.3 ADEOS is NASDA's first satellite dedicated to investigating global changes.

2.3.1 In order to assess the green house effect caused by CO_2, the carbon cycle should be investigated. The absorption of carbon into the ocean is a missing link in the carbon cycle. The Ocean Color and Temperature Scanner (OCTS) will measure the ocean chromaticity. Using this information, scientists will be able to determine the amount of fixed carbon in the ocean. This measurement will be supplemented by the NASA Scatterometer (NSCAT) and the Polarization and Directionality of the Earth's reflectances (POLDER). The understanding of the carbon cycle is an important theme in the International Geosphere-Biosphere Program (IGBP).

2.3.2 NSCAT will measure the ocean surface wind profile. This data will be employed for wind driven ocean circulation mapping, wave prediction, weather forecasting, and storms research. The final science objective of NSCAT is to detect climatic fluctuations, and to enable coupling ocean and atmospheric models.

2.3.3 The total ozone concentration has been measured by the Total Ozone Mapping Spectrometer (TOMS) on Nimbus-7 of NASA since 1978. TOMS Data will be collected continuously with TOMS equipment aboard NASA's NIMBUS-7, the USSR's Meteor, and NASDA's ADEOS in this sequence. The Interferometric Monitor for Greenhouse Gases (IMG) and the Improved Limb Atmospheric Spectrometer (ILAS) will also measure the trace gas concentration. The combined data from IMG, ILAS and TOMS will give us a clear understanding of the atmospheric profile.

2.4 TRMM is a joint program of NASA, NASDA and the Communication Research Laboratory of Japan. The mission objective of TRMM is to measure precipitation in the tropical region. Tropical rainfall is regarded as the "Engine" for global climate change. The process of tropical rainfall varies rapidly in the spatial and temporal dimensions. In order to detect diurnal variation of this phenomena, TRMM will fly in a non-Sun-synchronous orbit.

3. Estimated Expenditures for Japan's Global Change Research

The budget details of the space based elements related to global change are summarized in the attached table.

The fiscal 1990 budget for the global environment conservation amounts to 442.8 billion yen. This is twenty three percent of the FY1990 science and technology-related budget, 1,919.6 billion yen.

4. Japanese Polar Platform

NASDA has been studying JPOP as an Earth Observing platform following the ADEOS, focusing on what JPOP shall measure taking account of the large international Earth observing complex, i.e. EOS-A/B, EPOP-M-1/N-1 for 1990's. At present, the design life of JPOP is assumed to be five years. NASDA's Earth observing platform does not have a concept of a "comprehensive" system like EOS-A. Most of the Earth observing systems currently planned will fly in Sun-synchronous orbits. There exists a strong desire to observe the Earth in the diurnal cycle. Whether JPOP will fly in a Sun-synchronous orbit or a non-Sun-synchronous orbit is one of the major issues of the JPOP concept.

5. Data Utilization

5.1 Recently we have seen several global mappings of the key geophysical parameters: World vegetation, Sea surface temperature, Ozone hole in the Antarctic, etc. Through these mappings, we can understand global changes. However, at present there are very few qualified data sets, and these data sets are difficult to access. A qualified data set must be global, suitable for the investigated phenomena, cover a sufficiently long time span, and be well validated. In order to obtain qualified data sets, we must invest not only the instruments and the platforms, but also the data information systems and the related research activities.

5.2 The policy, that the data from space should be widely distributed to the researchers who are interested in global change with appropriate cost compensation, is recognized in general. NASDA adheres to this policy. We are now planning to establish our Data and Information System by the time ADEOS is launched. The primary characteristics of NASDA DIS are as follows:
a. Produce qualified data sets
b. Distribute the data and datasets worldwide to researchers interested in global changes with marginal cost compensation.
c. Maintain compatibility with NASA Eos DIS and ESA DIS.

5.3 The procedures for distributing data to the research communities have not been established. The technical and management issues related to the data distribution shall be resolved through international coordination bodies such as the Committee of Earth Observation Satellites (CEOS) and the Earth Observation International Coordination Working Group (EO-ICWG).

6. International Cooperation on Space-Based Global Change Research

6.1 It is well recognized that international cooperation is indispensable for "global change" research. NASA, NOAA and NASDA have a rather long history of cooperation in this area. NASDA has been receiving LANDSAT series data since 1979. The ERS-1 data will be received at the NASA Fairbanks station. NASDA issued an Announcement of Opportunity for providing instruments on ADEOS. As a result of our announcement, NASA will fly two instruments, NSCAT and TOMS, and the Centre National d'Etudes Spatiales (CNES) POLDER on ADEOS.

6.2 The Earth Observation International Coordination Working Group (EO-ICWG) is the central international coordination body on instrument selection, orbit selection, data policy, and data management for mainly the large Earth observing complex foreseen in the late 1990s and beyond. Through the discussion of EO-ICWG, we have been able to avoid most duplication of instruments. Moreover the members of EO-ICWG have joined in a partnership to embark on an international venture, Mission to Planet Earth. Since the members of EO-ICWG are limited to the space station partners, the members of EO-ICWG should note that there remain potential contributors outside the EO-ICWG.

Table 1. Budget Detail

ERS-1	¥70.B (FY'85 - '92) including Synthetic Aperture Radar (SAR) ¥10.B Optical Sensors (OPS) ¥10.B
ADEOS	¥80.B (FY'88 - '95) including Advanced Visible, Near Infrared Radiometer (AVNIR) ¥8.B Ocean Color and Temperature Scanner (OCTS) ¥9.B
TRMM	¥60.M (for FY '90)
Data Processing	¥ 2.B (for FY '90)

Canadian Space Agency
President

8th Floor West
C.D. Howe Building
240 Sparks Street
Ottawa, Canada
K1A 1A1

Agence spatiale canadienne
Président

8e étage Ouest
Édifice C.D. Howe
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August 17, 1990

Congressmen Bill Nelson and Ralph M. Hall
U.S. House of Representatives
Committee on Science, Space and Technology
Suite 2321
Rayburn House Office Building
Washington, D.C. 20515
U.S.A.

Gentlemen,

Thank you for your invitation to contribute to the work of your Committee on Science, Space and Technology.

I list below responses to your request for information in the same order as your questions.

- Canada, as you may be aware, has been very active in global change research over recent years and will continue to pursue an equally vigorous programme in the future through participation in a variety of international activities such as the International Geosphere/Biosphere Program and the World Climate Change Program.

- This work is distributed across a number of government departments; to provide the sort of funding information you request is not possible in the time available.

- The RADARSAT mission will carry a Canadian designed and built synthetic aperture radar. A pamphlet describing the mission is enclosed. Canada also has a proposal for an instrument called MOPPIT submitted through the Earth Observation System announcement of opportunity. This instrument would measure atmospheric carbon monoxide and could measure methane concentrations. Canada is also contributing an instrument, WINDII to NASA's UARS satellite.

... 2

- Discussions are taking place at the present time on the possibility of the Canada Centre for Remote Sensing becoming a node in the EOSDIS network.
- We attach great importance to international cooperation in both ground and space segments and this applies particularly to earth observation missions. Among current projects are the RADARSAT mission, in partnership with NASA and NOAA, the polar platform elements of the space station conducted jointly with ESA, NASA and Japan and participation in the ESA ERS-1 and ERS-2 missions. Each of these projects will make an important contribution to global change research. Canada also actively participates in the read-out and utilization of operational remote sensing systems such as LANDSAT and SPOT and meteorological satellites and experimental remote sensing systems such as Japan's MOS and JERS.

I hope these replies are helpful. Please do not hesitate to write again if you would like more specific information on any of the above matters.

Yours sincerely,

Larkin Kerwin

Larkin Kerwin, C.C.

Enclosure

United States Department of State

Washington, D.C. 20520

September 27, 1990

Dear Mr. Chairman:

Following the hearing on July 24, 1990 at which Mr. Richard J. Smith testified, additional questions were submitted for the record.

Please find enclosed responses to those questions.

Sincerely,

Janet G Mullins

Janet G. Mullins
Assistant Secretary
Legislative Affairs

Enclosures:
As stated.

The Honorable
Ralph M. Hall, Chairman,
Subcommittee on International Scientific Cooperation
Committee on Science Space, and Technology
House of Representatives.

Q: Since the Second Meeting of the Parties to the Montreal Protocol, have India and China joined the Protocol as was indicated by their delegations? Have additional developing countries indicated a willingness to become parties to the Protocol since the London meeting?

A: NEITHER INDIA NOR CHINA HAVE BECOME PARTIES TO THE PROTOCOL SINCE THE JUNE MEETING IN LONDON. HOWEVER, SINCE THAT TIME, BANGLADESH, GAMBIA, LIBYA AND POLAND HAVE JOINED THE PROTOCOL.

Q: The mechanism for funding Article 5 countries' participation in the Protocol will be based on "agreed incremental costs." Can you elaborate more specifically on what is meant by this term? What methodologies will be used to determine "incremental costs"?

A: IN RESPONSE TO YOUR QUESTION ON "INCREMENTAL COST," I ENCLOSE A COPY OF A UNEP REPORT WHICH IS ILLUSTRATIVE OF THESE KINDS OF COSTS. I BELIEVE THIS WILL BE HELPFUL IN UNDERSTANDING THIS CONCEPT.

Q: The U.S. currently spends far more money on both understanding and monitoring the ozone layer than most other countries. Is there likely to be a shift in this burden in the foreseeable future? Over the long term?

A: WHILE IT IS TRUE THAT THE U.S. CURRENTLY SPENDS MORE THAN OTHER COUNTRIES ON RESEARCH ON THE OZONE LAYER, WE EXPECT OTHERS TO DO INCREASINGLY MORE IN THIS AREA IN THE NOT-TOO-DISTANT FUTURE. WE AGREE THAT THE BURDEN OUGHT TO SHIFT IN THIS RESPECT, AND WILL MAKE THIS POINT IN APPROPRIATE INTERNATIONAL FORA.

Drafted:OES/ENV:GUsrey:eam
Doc. 634 9/14/90

Clearance:OES/ENV:DMason

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

October 11, 1990

Dear Mr. Nelson:

Thank you for your letter of September 5 to Dr. J. Thomas Ratchford enclosing a copy of his testimony from the July 24 hearing on international cooperation in Earth Observing System activities. That transcript has been edited and returned.

I have enclosed responses to additional questions from the July 24 hearing. If I can provide additional information, please let me know.

I have sent a similar letter to Mr. Hall.

Sincerely,

D. Allan Bromley
Director

Enclosure

Mr. Bill Nelson
Chairman
Subcommittee on Space Science and Applications
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, D.C. 20515

ANSWERS TO QUESTIONS POSED BY RALPH HALL AND BILL NELSON

QUESTION: Many observers believe there is a need for an international equivalent to the U.S. government's Committee on Earth and Environmental Sciences, to balance global program needs and priorities with global funding limitations?

a. Is the Administration's thinking evolving in this direction?

b. Could any existing international organization fill this purpose within its present mandate?

c. What existing international organization might provide the best venue for an expanded mandate to balance global program needs and priorities with global funding limitations?

ANSWER: The Federal Coodinating Council for Science, Engineering and Technology (FCCSET) formed the interagency Committee on Earth and Environmental Sciences (CEES) in April 1987 to increase the overall effectiveness and productivity of federal R&D efforts directed toward understanding of the earth as a global system.

The CEES recognized at the outset that successful implementation of the complex scientific agenda outlined in the U.S. Global Change Research Program (GCRP) would require thoughtful and careful integration of this program with those of national agencies and CEES-like coordinating groups in other countries; intergovernmental organizations (e.g., United Nations agencies such as the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC), and the United Nations Environment Programme (UNEP)); non-governmental scientific organizations such as the International Council of Scientific Unions (ICSU); and private business and industry.

Thus, OSTP has been and is working with the CEES and its member agencies towards developing cost-effective international arrangements to facilitate coordination and communications among all the players in the global change research effort. It is of utmost importance that such arrangements foster a broad sense of ownership of global change research. Dr. Robert Corell, the Chairman of the CEES Working Group on Global Change, has reported to you that representatives of national funding agencies, including some from CEES-like committees in other countries, met in January and July of this year and will meet again in February 1991.

This group, now referred to as the International Group of Funding Agencies for Global Change Research (IGFA), will continue to work towards facilitating communications among the national funding agencies with the objective of eliminating overlaps and filling gaps in funding of important global change research.

An international partnership for global change research requires active participation of the four major players in international global change research -- the science community, agencies of governments, intergovernmental organizations, and industry. It is arguable that no existing international organization has or could easily be broadened to adequately represent all four groups. Existing science-oriented UN agencies either are so sharply focussed that they lack the breadth to oversee an effort of this complexity or lack the management capability and national support to do so. Other UN bodies are primarily focussed on policy and/or economic objectives which could torque global change research to immediate political goals, with the likely result of compromising severely the scientific quality and objectivity of such research.

It is essential to not only continue discussions of global change research at the international level, but also to develop international arrangements for the coordination necessary to assure cost-effectiveness of the highest priority global change research. The work of the International Group of Funding Agencies for Global Change Research (IGFA) and the ICSU Forum could develop a basis for such coordination.

The IGFA process is also responsive to U.S. needs especially because it assures that support of global change research is reviewed and approved through national funding mechanisms which, in the case of the United States, results in timely and effective review and approval of funding through the traditional budget process involving both the Executive and Legislative Branches of Government. We therefore see no need at this time to expand the mandate of the IGFA or of other international organizations or to establish new mechanisms to provide additional international coordination of global change research.

RESPONSES TO WRITTEN QUESTIONS BY DR. FREDERICK HENDERSON

ANSWERS TO HOUSE QUESTIONS SEPTEMBER 6

1. **REGARDING MY WRITTEN TESTIMONY OF JULY 24TH, I STATED THAT A "MAJOR GAP" IN THE U.S. GLOBAL CHANGE RESEARCH PROGRAM IS "THE LACK OF MECHANISMS FOR INDUSTRIAL INPUT."**

   A. WHAT TYPE(S) OF MECHANISMS WOULD YOU RECOMMEND?

In our current dialogue with the Committee on Earth and Environmental Sciences (CEES) and the Office of Science and Technology Policy (OSTP), it is our understanding that the CEES, as part of the Federal Coordinating Committee on Science, Engineering and Technology (FCCSET), can not have direct participation of industry in its activities. Accordingly, we have proposed in a letter (see attached) to Dr. Williams Phillips, Associate Director OSTP, that a parallel Private Industry Committee on Earth and Environmental Sciences (PICEES) be created, perhaps under the auspices of the President's Council of Advisors on Science and Technology (PCAST). PICEES would serve to coordinate cooperative industry and government global change research with academia through some linkage (eg, a subset of PCAST) with the CEES. Since the Phillips letter was written, the CEES has moved to form a Private Industry-Government Interface ("PIGI") working group with the CEES to serve to link the CEES with industry efforts for cooperative global change research.

Because "PIGI" will undoubtedly face growing interest from numerous industry organizations in linking cooperative research on global change, mitigation and response and other groups within the CEES, the Geosat Committee has recommended that the PICEES be formed to act as an industry interface to PIGI/CEES. If industry can organize an ongoing PICEES, it should embody the following characteristics (see attached):

PICEES - An industry organized group with broad cross industry representation.

No lead industry organization.

Ongoing working linkage to PICI/CEES.

Promote coordination and cooperation in Global Change Research between Industry and Government with Academia.

Leverage mutual assets including data and information for mutual benefits.

Focus on research issues, not policy.

B. SHOULD THERE BE SOME FORM OF INDEPENDENT "EOS USER'S ADVISORY PANEL" TO IDENTIFY NEEDS AND CONCERNS OF ALL RESEARCHERS IN INTERNATIONAL DISCUSSIONS REGARDING EARTH OBSERVING SYSTEMS?

NASA has tended to resist such panels in the past and preferred to use the EOS Investigators Science Advisory Panel and appropriate committees of the National Research Council. While some industry input has been provided through the NRC, such input does not serve on a continuing basis, is advisory only and does not serve in a planning, implementation, or oversight manner. The EOS Investigator Science Advisory Panel also does not have ongoing user industry representation. An important example of our concern about the lack of such industrial and user participation is NASA's development of its EOS data policy which does not adequately provide for industrial access to EOS data for applied research. The Geosat Committee requests either ongoing input and representative participation for the industrial applied scientific research community on NASA's present EOS and EOS-DIS committees, or the creation of an "EOS User's Advisory Panel" with industry representation.

2. DO YOU SEE A DANGER THAT THE U.S. WILL FUND MOST OF THE BASIC RESEARCH IN EOS, AND THAT OTHER NATIONS WILL DEVELOP THE APPLICATIONS THAT WILL LEAD TO COMMERCIAL SPIN-OFFS FROM THIS PROGRAM?

Yes, we have such concerns as expressed, in part, in our 24 July testimony response to question 1, pages 2-4.

The Geosat community is generally not too concerned that other countries will develop commercial spin-offs per se, but rather that access to U.S. funded basic EOS research will be distributed to other countries where their industry will have greater access to such basic research at a competitive disadvantage to U.S. industry. This is because under present NASA EOS data policy, U.S. industry is not encouraged to conduct cooperative or applied research with EOS data IN A COMPETITIVE APPLIED RESEARCH MODE". Other countries have better institutional arrangements between their industry and government to share government derived and obtained (i.e., from NASA) data and research for their national economic development. Therefore, we are concerned that U.S. industry will not have the same relative ease of access to U.S. EOS data and research as might our international counterparts. This difference in industrial access to EOS data and research could lead to unfair international development of commercial spin-offs of U.S. funded EOS data and research. It is important that NASA make assurances that such unfair advantages will not be taken by their international partners in EOS, and that US industry will have fair access to any such international commercial spin-offs of U.S. funded EOS data and research.

3. IN YOUR TESTIMONY, YOU SUGGESTED DIFFERING DATA POLICIES FOR THREE LEVELS OF USE: 1) BASIC SCIENCE IN THE PUBLIC DOMAIN,

2) APPLIED RESEARCH BY INDUSTRY, SHORT OF COMMERCIAL USE, AND
3) INDUSTRY USE FOR COMMERCIAL PURPOSES.

A. PLEASE ELABORATE FURTHER ON HOW ONE MIGHT DISTINGUISH BETWEEN THE SECOND AND THIRD CATEGORIES?

In testifying on behalf of providing EOS data access to industry and other end users for applied research, our concern is that NASA's policy adheres to too strict an interpretation of what is meant by "for any commercial purpose" in the amended Section 502 of the Landsat Act of 1984 under public Law 100-47 of October 30, 1987 as further defined in NASA's published EOS Data Policy by "for commercial distribution on a non-discriminatory basis to non-research/non-operational users."

Unfortunately, "commercial use" is not defined with respect to "applied research by commercial users" nor is it considered by either the Landsat Act or its amendment, or by either the NASA EOS Data Policy or the Data Management for Global Change Research Policy Statements of the Interagency Working Group on Data Management for Global Change, of June 1990. In resolving this data access question, it might be more judicious to amend the NASA data policy then further amend the Landsat Act at this time.

The Geosat Committee believes that industry should have access to EOS data for both basic and applied research purposes as well as commercial uses as defined by the Landsat Act and amendments and by the NASA policy. We support the ultimate provision for commercial access to EOS data for bona-fide non-research/non-operational commercial uses under provisions of the amended Landsat Act with the proviso that, given the enormous size and complexity of the EOS and EOS-DIS systems, NASA will develop a more workable mechanism for any en masse sales of EOS data than was experienced for the Large Format Camera. NASA might consider testing such en block mechanisms by finally offering SIR-B radar data to the end user community and include the user community in an advisory role in NASA preparation for such sales.

Regarding industrial applied research, we are concerned that NASA and other agencies do not appreciate or recognize the existence of extensive basic and applied research activities in the end user industrial community. A problem is that while some industrial research is focused on basic research for scientific knowledge, other industry research is generally dedicated to short term applications which might lead to operational commercial use in an internationally competitive world. Furthermore, both basic and applied industry research often includes the integration of EOS type data with other industrial databases or programs which are legitimately proprietary for competitive or for potential liability or other legitimate business purposes. These "grey area" distinctions between basic and applied research between industry and government are further clouded when discussing access to EOS data for cooperative industry research for global change studies, environmental management and earth observations applications. In our efforts to establish linkage and further industry and government cooperation in these areas of research, it appears that there is support for the concept that industry and government cooperation would lead to a better understanding of global change issues and in establishing what is best for both to intelligently mitigate and respond to better managing our environment.

B. WHAT SPECIFIC "REASONABLE PUBLICATION REQUIREMENTS" WOULD YOU RECOMMEND THAT MIGHT ATTACH TO THE SECOND CATEGORY?

As we understand the current data policies of both NASA and the Interagency Working Group on Data Management of Global Change, the provisions of the Landsat Act and its 1987 amendments, NASA's data policy differs from the above primarily in adding their research agreement item 2) requiring "research users" to "make available to the research community their detailed results, including data, algorithms, and models at the time their research in accepted for publication". The Landsat Act as amended in 1987 provides only that "(1) a complete and timely disclosure of the results of such research and development in made in the open technical literature or is otherwise made publicly available". This issue is not addressed specifically in the June 1990 IWGDMGC data policy statement.

The Geosat Committee does not object to any other provisions of the NASA policy as we understand them. But, we believe that our mutual interests in fostering industry-government cooperation on global change studies utilizing EOS data would be greatly strengthened by NASA's willingness to comply with the following recommendations:

a. Modify NASA's research agreement item 2) to accommodate the withholding from public publication those data, algorithms, and models which legitimately are proprietary on some mutually agreed basis between industry and NASA.

b. Establish an Industry Peer Review Panel under NASA to

    1. determine the basis on which proprietary data, algorithms, models, etc. might be legitimately withheld from publications for the purposes of the intent of the EOS data policy, and

    2. determine how "the results of such research and development is...otherwise made publicly available" (e.g., not by publication in the open technical literature; see Sect. 504 (1), PL100-147, the Landsat Act Amendment of October 30, 1987).

The Geosat Committee supports the intent of other requirements of the NASA EOS Data Policy including the purpose for publishing the results in the public domain to contribute to general public knowledge. We believe that if the recommendations above are implemented by NASA, our mutual interests in developing cooperative industry-government research on global change, environmental management and earth observations applications will be encouraged and furthered in the best interests of the United States under the overall principles of the NASA and IWGDMGC Data Policies and of the Landsat Act and its amendments.

Geosat

THE GEOSAT COMMITTEE, INC.
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Norman, OK 73019-0315
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Mr. Oliver [illegible]
[illegible] INTERNATIONAL

April 20, 1990

Dr. William Phillips
Associate Director, Office of
Science and Technology Policy
Executive Office of the President
5026 NEOB
725 17th Street, N.W.
Washington, D.C. 20506

Dear Bill,

First, I would like to express my appreciation on behalf of the Geosat Committee, Inc. for the opportunity to meet with you, Jules Blake, Paul Dresler and other members of the Committee on Earth Sciences (CES), White House Office of Science and Technology Policy (OSTP), and EPRI on April 2, 1990. I believe we made some headway in our efforts to find mechanisms for improving industry and government cooperation in global change and environmental research.

Although there are presently uncertainties within the science community as to the nature, scope, and direction of global change, particularly climate change, mounting public concern dictates the formulation of policy. Policies now under consideration will profoundly affect the businesses of the energy, mineral, food and fiber industries. Thus, it is in their self interest to contribute in a major way to cooperative research leading to new knowledge of global change.

The purpose of this letter is to state support for the concept we discussed of creating a balanced industry committee that would parallel CES and provide a linkage mechanism for industry-government cooperative research on global change and environmental management. An inventory of relevant industry research, as discussed in the December Geosat-CES meeting and further proposed by EPRI in April, should be a good first step. However, care must be taken that such an inventory is broadly representative of the diversity of industry and not associated with any particular interest groups.

A comprehensive and far reaching program has been put in place by CES through its U.S. Global Change Research Plan (USGCRP), but it presently lacks significant linkage with the industrial sector. The resource and manufacturing industries have very significant scientific, technological, and economic capabilities with qualified people and data bases that in many ways complement those of the agencies and national laboratories represented by the CES. What we recommend is that these assets be coordinated in a parallel industry-academic effort to supplement the USGCRP. We believe that such an effort, if properly linked to the CES programs, would greatly strengthen the ability of the United States to understand global change and develop effective and economically feasible policies to better manage industry and main's impact on the earth's environment. In order to establish a balanced industry-university effort and to link it to CES programs under the USGCRP, we support the suggestion made by Paul Dresler, CES, that "the White House Office of Science and Technology Policy (OSTP) act to facilitate a linkage between the government and industrial sectors and thereby enhance opportunities for their mutual collaboration".

As we have discussed, we further recommend the OSTP act to cause a parallel Industry Committee on Earth Sciences be created under the Presidential Council of Advisors on Science and Technology (PCAST) which would serve to coordinate cooperative industry and government research with academia on global change. This committee, "PICES" (PCAST Industry Committee on Earth Sciences), would work with the CES and industry through the auspices of the PCAST and OSTP. OSTP should provide the guidance for 'PICES'. In particular, OSTP should ascertain that PICES' membership is well balanced to fairly represent diverse inter-industry interests and that its focus is on research necessary for sound policy-making. One objective of the PICES should be to produce an annual document similar to the USGCRP. While not an industry budget plan, the document could delineate appropriate current and planned industry research and identify key areas of needed research. The document could also identify where industry and government could share and coordinate data and research efforts, as well as report on the results.

In support of the above recommendations, the Geosat Committee, Inc. proposes to organize a resource industry-government-academia forum on cooperative global change research including the use of earth observations to take place later this year. This forum would focus on key science issues as well as review the newly published CES 1991 US Global Change Research Plan and inventory the appropriate on-going environmental and related research programs and the scope of the investment therein by the participating resource industries. From the review of USGCRP and industry research, gaps in needed research and areas for cooperative industry-government-academia research will be summarized in a report. Forum participants will be encouraged to develop recommendations for a coordinated industry research program that builds on the present industry-university efforts and would complement the CES program. Finally, if there is an agreement that this sort of major industry-university effort is desirable, the forum participants can explore the implications with their individual managements and prepare for follow-up meetings and implementation. In conducting this forum, the Geosat Committee, Inc. will seek the active participation and support from the CES, OSTP, and PCAST as appropriate.

Bill, again, thank you for your interests in these issues. I hope that this letter provides you with some useful recommendations for your future deliberations with both CES and PCAST.

Respectfully,

Fred Henderson

Frederick B. Henderson III, Ph.D.
President

FBHIII/lm

cc: Geosat Board of Directors
Jules Blake, OSTP
Charles Drake, PCAST
Paul Dresler, CES
Barnet Groten, OU/Energy Center
Tom Maginnis, CES/NOAA
David Packard, PCAST
Ari Patrinos, CES/DOE
Michael Tinkleman, EPRI
Bill Sugg, ITA/DOC

Cooperative Linkages for Global Change Research (GCR)

PIGI ◄──► "PICEES"

5/89 GEOSAT - Dallas Peck, Chairman, Committee on Earth and Environmental Sciences (CEES)
EOS Data Access
Industry Role in GCR

9/89
12/89 GEOSAT - CEES
Data Access
Industry Government Linkages for GCR
Workshops

4/90 GEOSAT - CEES - Office of Science and Technology Policy (OSTP) - EPRI
Industry Government Linkages

5/90 - 7/90 President's Council of Advisors for Science and Technology (PCAST) Reviews
Private Industry -Government Interface (PIGI)/CEES Formed

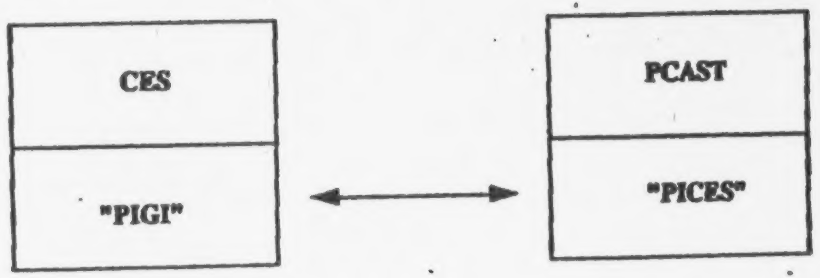
[redacted]

10/90 Industry Meeting (Hosted by GCC)
Discuss forming "PICEES" Steering Committee
Discuss Industry GCR

2/90 GEOSAT - CEES - Others Workshop
GCR Related Research Priorities
EOS Applications

GEOSAT

Industry/Government linkage for cooperative R&D for Earth Observations, Global Change Studies, and Environmental Management



CES

"PIGI"

PCAST

"PICES"

GEOSAT 9/90

PICEES
(Private Industry Committee on Earth and Environmental Sciences)

- Industry Group with Cross Industry Representation
- No Lead Organization (Agency)
- On-Going Working Linkage to PIGI (Private Industry - Government Interface)
- Promote Coordination/Cooperation in Global Change Research Between Industry and Government
- Leverage Mutual Assets for Mutual Benefits
- Research not Policy

GEOSAT